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FIELD EVALUATION OF UNDERGROUND STORAGE TANK SYSTEM LEAK DETECTION SENSORS

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EXECUTIVE SUMMARY

State Water Resources Control Board (SWRCB) staff have been conducting a comprehensive evaluation of the effectiveness of underground storage tank (UST) and piping systems, and associated leak detection equipment. The evaluation includes: a field-based research project to determine the frequency and source of releases from single and double-walled UST systems, a field evaluation of automatic tank gauges and automatic line leak detectors, a survey of statistical inventory reconciliation service providers, and a field evaluation of leak detection sensors. This report contains the findings of the field evaluation of leak detection sensors, which are the primary form of leak detection in double-walled UST systems. California's UST population currently consists of roughly 75% double-walled systems, making sensor performance a key element in the detection of leaks from UST systems statewide. The importance of sensors will only increase as older single-walled systems are phased out of service and replaced by double-walled systems.

Leak detection sensors are typically located in tank interstitial spaces, piping sumps, under-dispenser containment, and monitoring wells within excavation liners. They may also be located in groundwater monitoring wells or soil-vapor monitoring wells surrounding the tank system, although no such facilities were included in this field evaluation. California regulations require that all leak detection equipment be functionally tested and certified by an authorized service technician on an annual basis. This report was based largely on data collected from 789 sensors at 124 UST facilities during routine annual testing and certification. Also discussed in this report are 71 responses to an on-line survey on sensor performance, completed by service technicians and inspectors. It is important to note that federal regulations and other state UST programs do not require annual certification of monitoring equipment. One may assume that the sensor performance problems identified in this field evaluation would be significantly more common if California did not require the annual certification of monitoring equipment.

Federal and California regulations require that leak detection equipment be evaluated by an independent third-party testing organization in accordance with recognized protocols. However, these evaluation protocols are designed only to test sensor functionality in a laboratory setting. The objective of this field evaluation was to assess sensor functionality under field conditions. We also set out to determine the adequacy of annual certification testing procedures, and to determine whether sensors in the field perform in a manner consistent with the specifications outlined in their third-party evaluations.

The data collected in this field evaluation demonstrate that sensors can be a reliable form of leak detection only when properly installed, programmed, maintained, and operated. Most problems observed in this field evaluation are due to improper installation and programming of sensors, poor or infrequent maintenance at UST facilities, ignoring alarms, and tampering with monitoring equipment. Poor design, construction, and maintenance of secondary containment systems were also common. Additionally, sensor design and materials played a role in some of the failures observed.

Findings - Effective performance of sensors is also dependent upon the performance of the secondary containment in which they are installed. Therefore, this report's findings are presented in two categories: sensor performance and secondary containment performance.

Sensor Performance - Approximately 12% of sensors had one or more problems at the time of testing. The most common problems observed were sensors raised from the low point of the secondary containment, sensors failing to alarm when tested, and sensors failing to shut down the turbine pump in the event of an alarm (when programmed to do so).

Secondary Containment System Performance - Problems with the performance of secondary containment were more common than problems with sensors. Secondary containment must be kept clean and dry in order for sensors to perform properly; however, water was found in over 10% of secondary containment systems. Liquid product was present in an additional 3.5% of systems. Overall, 31% of the facilities visited in this field evaluation had water or product in one or more areas of the secondary containment system.

Recommendations - Based on the findings of this field evaluation, we propose the following recommendations to improve sensor performance and the effectiveness of leak detection programs based on the use of sensors:

1. Periodic inspection and functional testing of sensors and secondary containment are essential to reliable performance. California currently requires annual certification of monitoring equipment, and triennial integrity testing of all secondary containment. The United States Environmental Protection Agency (U.S. EPA) and states not currently requiring annual certification of monitoring equipment and periodic testing of secondary containment should consider implementing such requirements.
2. Sensor manufacturers should continue to refine sensor design and field testing procedures. Sensors must be designed to reliably operate under the conditions found within the secondary containment of an UST. Field testing procedures should involve functional testing of the sensor, and should accurately determine the ability of the sensor to detect a release.
3. Standard third-party evaluation protocols for sensors should be revised to better reflect operating conditions found in the field. SWRCB UST program staff has been active in the efforts of the National Workgroup on Leak Detection Evaluations to improve the evaluation and review process.
4. Regulatory agencies should call for more thorough training of personnel who install, service, and operate UST leak detection systems. A recent California statute requires training for these individuals, and the SWRCB is currently developing regulations to implement a training standard statewide.
5. Regulatory agencies must have authority to take enforcement action against UST owners and operators who tamper with leak detection equipment. The SWRCB has proposed legislation that would grant regulators administrative enforcement authority, and allow them to "red-tag" facilities that are significantly out of compliance.

INTRODUCTION

Secondary containment for most UST systems has been required in California since January 1, 1984¹. These “double-walled” systems employ liquid sensors in the interstitial space of UST components, the space between the inner and outer wall of the component. Sensors are designed to detect the presence of liquid in the interstitial space, providing the primary (and often only) form of leak detection in double-walled UST systems. Therefore, their reliable performance is a critical factor in preventing the release of hazardous substances into the environment.

To comply with regulations and provide the most effective leak detection, sensors should be installed at the low point of the secondary containment [i.e., at the bottom of the tank interstice, in turbine sumps (where liquid from leaks in double-walled piping will collect), and in under-dispenser containment (where under-dispenser leaks collect)]. Sensors can also be found in fill sumps, monitoring wells, or anywhere else leaking liquid from the primary containment may collect. Regardless of location, all sensors are designed to perform the same task: to alert the UST operator that liquid is present in the monitored area. This alert is typically accomplished either by activating an audible and visual alarm at a control panel, or by stopping the flow of product through automatic valve closure or pump/dispenser shutdown.

California regulations require that all UST monitoring equipment installed on a UST system (including sensors) be tested and certified annually by a qualified technician². Testing and certification are often witnessed by an inspector from one of the 104 local government agencies throughout the state that implement the UST regulations. The local regulatory agencies implement the statewide UST program, which is overseen by the SWRCB. As the statewide regulatory agency, SWRCB staff often receive comments from technicians and inspectors about the effectiveness of UST monitoring equipment, especially if the equipment is not performing properly. During Spring of 2000, inspectors brought the following specific concerns to our attention:

- The inability of discriminating sensors to detect a layer of hydrocarbon-based product (i.e. gasoline) floating on top of water and to properly distinguish between water and product;
- The inability of polymer-strip hydrocarbon detecting elements to quickly and reliably alarm; and
- The inability of polymer-strip hydrocarbon detecting elements to return to effective operation (recover) after exposure to hydrocarbons.

To determine how pervasive the problems were, SWRCB staff launched a field evaluation of sensors. The first phase (Phase I) of this evaluation was a cooperative effort between SWRCB staff, Veeder-Root representatives, and UST inspectors from the Santa Ana Fire Department, City of Santa Monica, and Oakland Fire Department. Phase I focused exclusively on discriminating sensors manufactured by Veeder-Root. Data were collected from 67 Veeder-Root discriminating sensors at 18 UST facilities in Phase I, between August 2000 and November 2000. Sensors were evaluated for their ability to detect and discriminate between product and

¹ California Health and Safety Code, Chapter 6.7, Section 25291(a)

² California Code of Regulations, Title 23, Section 2637(b)

water, using a test method proposed by UST inspectors and further refined by Veeder-Root and SWRCB staff. The information collected provided a clearer picture of how sensors perform in the field. Although a great deal of information was collected in Phase I, the data was limited to Veeder-Root discriminating sensor models only.

With funding from U.S. EPA, we were able to conduct a second phase of field evaluations (Phase II). Phase II was conducted to evaluate the functionality of all types of liquid sensors used to monitor UST systems, including discriminating and non-discriminating sensors of all makes and models. The range of objectives for Phase II was broader than that of Phase I. Field data for Phase II was collected between June 2001 and October 2001. This report includes the findings of both phases, but focuses primarily on Phase II. A summary of Phase I testing results is included in Appendix I.

SCOPE OF WORK

Objectives of the Field Evaluation

The purpose of this field evaluation was to assess the functionality of liquid sensors used to monitor UST systems. The focus was on “real world” effectiveness, with testing performed at operating UST facilities. The field evaluation was designed to:

- evaluate the functionality of sensors;
- check the adequacy of field-testing procedures for sensors (or work with manufacturers to develop field-testing procedures if they were not already available);
- determine whether sensors in the field perform consistently with their third-party evaluations; and
- determine whether the standard U.S. EPA third-party evaluation protocols for sensors are appropriate for each of the sensor types evaluated.

A copy of the workplan for Phase II is included in Appendix II.

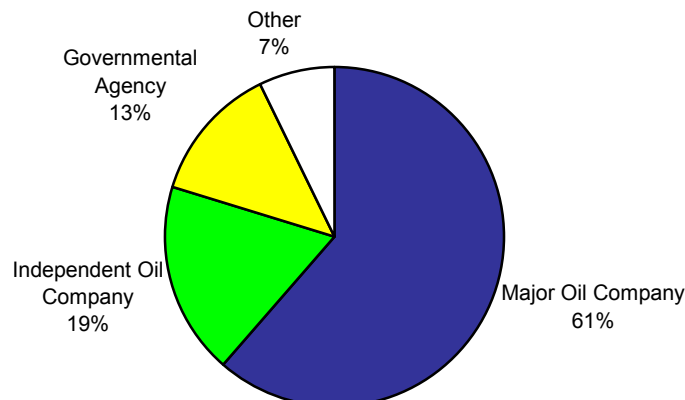
Facility Selection Process

For the first phase of this field evaluation, all facilities were located within the jurisdiction of three agencies assisting in the project; Oakland, Santa Ana, and Santa Monica. All facilities were equipped with Veeder-Root discriminating sensors, and all were owned by major oil companies. In contrast to Phase I, Phase II data were collected from a variety of sensors at a variety of facilities throughout California. An effort was made to include a wide variety of geographic locations, facility ownership types, tank system configurations, sensor manufacturers, sensor applications, and sensor operating mechanisms.

Facility Ownership

Of the 124 facilities in this field evaluation, 76 retail fueling facilities owned by major oil companies and 23 were retail fueling facilities owned by independent marketers. Other types of UST facilities were also included, such as emergency generator fueling facilities, fleet fueling facilities, unmanned card-lock facilities, and government facilities. Figure 1 shows the distribution of facilities in this field evaluation, by ownership.

Figure 1 - Facility Ownership



Geographic Location

Data from facilities within 28 local regulatory jurisdictions throughout the state were included in the field evaluation. Table 1 lists the various regulatory agencies and associated number of facilities evaluated in the field evaluation. A map of California showing the distribution of test facility locations is included in Appendix III.

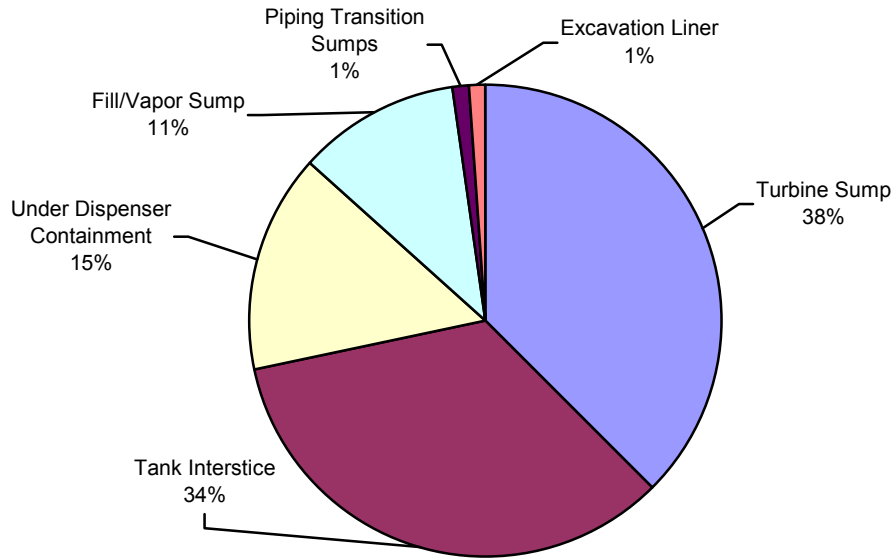
**Table 1 - Distribution of Test Facilities,
by Regulatory Agency Jurisdictions**

Agency	# of Facilities
Anaheim Fire Department	2
Butte County Environmental Health Division	1
Calaveras County Environmental Health Department	1
Orange City Fire Department	1
Colusa County Environmental Health	1
Contra Costa Hazardous Materials Program	3
Fremont Fire Department	2
Fullerton Fire Department	5
Long Beach Fire Department	2
Los Angeles County Department of Public Works	5
Mendocino County Environmental Health Department	1
Mountain View Fire Department	16
Napa County Hazardous Materials Section	3
Newark Fire Department	1
Oakland Fire Department	13
Placer County Department of Environmental Health	3
Sacramento County Environmental Health Department	15
San Bernardino Fire Department	11
San Diego County Department of Environmental Health Services	1
San Francisco Department of Public Health	2
San Leandro Fire Department	1
San Mateo County Environmental Health Department	2
Santa Ana Fire Department	3
Santa Monica Environmental Program Division	7
Solano County Environmental Health Services	16
Torrance Fire Department	2
Yolo County Environmental Health Department	3
Yuba County Emergency Services	1
Total # of Facilities	124

Sensor Location

Since all monitoring equipment is functionally tested during the annual certifications at which field data was collected, sensors from various locations within the tank system are included in this field evaluation. Figure 2 shows the distribution of sensors, by location within the tank system. Note that no groundwater monitoring well or soil-vapor monitoring well sensors are included in this field evaluation. While we did not specifically exclude such sensors, they are very rarely used in California.

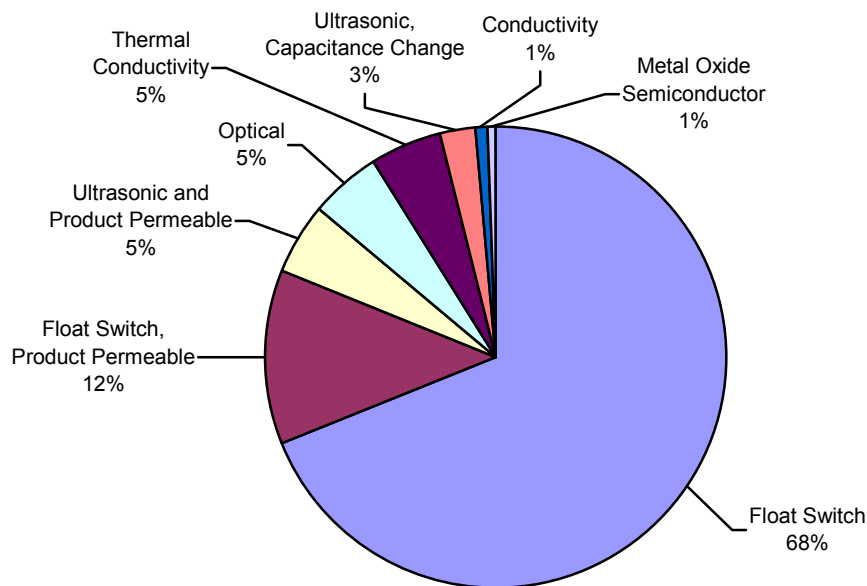
Figure 2 - Distribution of Sensor Locations

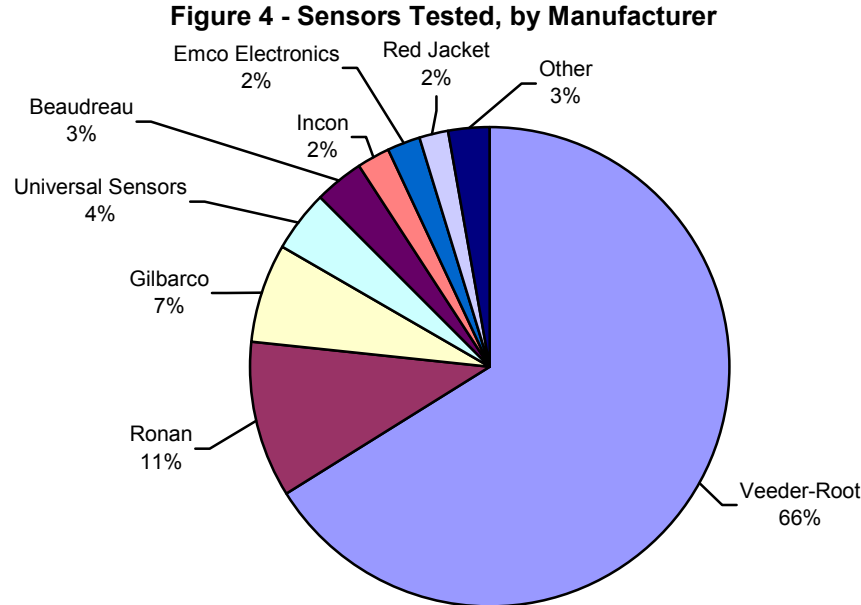


Sensor Manufacturer and Operating Mechanisms

Facilities for Phase II were selected with the intention of including a wide variety of sensor manufacturers and operating mechanisms. Overall, sensor selection represented 8 different operating mechanisms and 15 different manufacturers. Figure 3 shows a distribution of sensors in this field evaluation, by operating mechanism. Figure 4 shows a distribution of sensors in this field evaluation, by manufacturer. In spite of our efforts to include a wide variety, the majority of sensors tested were float switches manufactured by Veeder-Root. Such sensors are by far the most prevalent in California.

Figure 3 - Sensors Tested, by Operating Mechanism





Note: Veeder-Root and Gilbarco sensors are produced by the same manufacturer

Scheduling and Coordination

As part of the annual monitoring system certification required for UST systems in California, a qualified technician must functionally test each leak detection component. To minimize the impact on UST facility operations during Phase II data collection, SWRCB staff accompanied service technicians and regulatory agency inspectors during scheduled annual monitoring system certifications. Field data were collected while the technician performed this testing, and the technician's routine test procedures were not interrupted.

Many inspectors and service technicians provided insightful information and data that would not have otherwise been obtained. In total, inspectors were present at 79 of the 106 facilities (75%) evaluated in Phase II. In cases where regulatory agencies do not routinely have inspectors witness annual monitoring systems certifications, SWRCB staff coordinated with the service technicians directly. In total, technicians from 19 service companies performed the sensor testing in this field evaluation.

Data Collection Process

Data for Phase II were collected from 722 sensors in the field between May 2001 and February 2002. Where applicable in data analysis, data from the 67 sensors tested during Phase I were also included. During Phase II, SWRCB staff used a Sensor Data Collection Form to record the make, model, location, condition, response, and recovery times for each sensor tested. Data about facility location, UST system construction type, and personnel present were recorded on the Site Data Collection Form. All field data collected in Phase I was recorded on the Veeder-Root Discriminating Sensor Field Performance Test Form. A copy of each form is included in Appendix IV.

Limitations of Data Collection

Because all Phase II data were collected with the intent of minimum impact on the operation of the UST facility, not all of the desired tests were performed. For example, we suggested that discriminating sensors should be tested both in product and water, and that non-discriminating sensors be tested in water. However, many discriminating sensors were not tested in product, but rather by inverting or submersing the sensor in water. Non-discriminating float switch sensors were often tested by inverting the sensors, rather than by submersing them in water.

When possible, sensor response time was measured from the time the sensor was immersed in liquid (or flipped in the case of some float switch sensors) to the time an alarm was activated at the control panel. In cases where the control panel could not be seen or heard from the sensor location, the time from sensor immersion/flip to the time of pump shutdown occurred was used. In cases where the control panel could not be seen or heard from the sensor location and the monitoring system was not programmed for pump shutdown, field staff would move between the sensor location and the control panel, making their best estimate as to the actual sensor response time.

Several SWRCB staff were involved in field data collection. To reduce subjectivity during data collection, staff met periodically throughout the evaluation to discuss the standards used in recording data. These meetings helped minimize the impact that inconsistent standards may have had on the data collection process. For example, some sensors were found near, but not quite at the lowest point of the secondary containment. One person might consider this sensor to be raised from the lowest point, while another person might consider it close enough to the proper location to record it as being at the lowest point. Through periodic staff meetings, standards were agreed upon and applied uniformly by all staff involved in data collection.

Another factor that may have impacted the results of this field evaluation is the practice of performing maintenance at a facility just prior to the annual monitoring certification. Some inspectors have stated that service technicians often perform these “pre-tests” to assure that the facility will be in regulatory compliance and the monitoring equipment will pass the annual certification. Problems such as failed sensors and water or product in sumps may have been corrected during a “pre-test”, meaning they would not show up during our field evaluation. If “pre-testing” occurred at facilities covered in this field evaluation, failure rates would be artificially lowered. Although SWRCB staff are not aware that any “pre-testing” took place, the possibility cannot be ruled out.

While the findings of this field evaluation are applicable to UST systems throughout the nation, it is important to note that our field data were collected exclusively in California, where annual certification of monitoring equipment is required. This means that a technician had already certified all leak detection equipment at the facilities as operational within the year prior to the data collection. It is reasonable to assume that failure rates may be higher in states where annual certification of monitoring equipment is not required, although such data are not available.

UST Sensor Field Evaluation Survey

To supplement the field data, inspectors and service technicians were polled to provide their personal experiences with sensor performance. Sensor surveys were distributed to regulatory agencies and UST service technicians who work with sensors on a regular basis. With the help of the California Certified Unified Program Agency (CUPA) Forum, an online version of the survey was also made available. A total of 71 surveys were completed, with 63 submitted by inspectors and 8 by service technicians. Copies of the survey and transmittal letter are included in Appendix V.

Data Analysis

To prepare this report, data from both phases of field evaluation were entered into a database. Additional information from sensor manufacturers' installation, testing, and operations manuals have also been used as reference materials. Sensor survey results have been reviewed, and in most instances they validate the field findings. However, the results of the survey are not always consistent with field data. In such cases, it is possible that survey respondents may have negative experiences with a specific sensor model's performance, which could cause them to believe that a particular problem is more widespread than it actually is. It is also possible that we were unable to collect sufficient field data to yield reliable findings in a particular area. In such instances, additional research may be needed to discover why field results differ from survey results.

Although the data collection forms and sensor surveys were designed to adequately record most data, there were many instances where important information could not be captured on a form. In these cases, the "comments" section was used. On the data collection forms, comments describe unique facility layouts, special testing procedures, and additional details on sensor condition and performance. On the sensor survey, the comments include respondents' observations of sensor performance, and suggestions on sensor improvements. Comments from the field data collection can be found in Appendix VI. Comments from the sensor survey can be found in Appendix V.

Failure Rates, by Sensor Make and Model

One objective of this field evaluation was to quantify failure rates for each sensor make, model, and operating principle. We attempted to locate and include facilities with a variety of monitoring equipment. Although 59 sensor models from 15 manufacturers were tested, it was not possible to test a statistically significant number of each model. Therefore, no statistically valid comparison can be made between manufacturers' products. Data on makes and models tested are summarized in Table 2. Sensor performance data by manufacturer are detailed in Table 3.

Failure Rates, by Sensor Operating Mechanisms

Efforts were made to collect enough performance data from sensors so that statistically valid determinations about operating mechanisms could be made. Sufficient data were gathered for float switch, optical, ultrasonic, and product permeable sensors. However, only a handful of capacitance change, thermal conductivity, or metal-oxide semiconductor sensors were included in the field evaluation. Therefore, the limited data may not be a statistically valid to determine the reliability of these latter operating mechanisms. Sensor performance data by operating mechanism is detailed in Table 4.

Table 2 - Number of Sensors Tested and Failures, by Model

Manufacturer	Model	Tested	Failed
Alpha Wire	Unknown	2	
Beaudreau	404	1	
	406	24	3
Emco	Q0003-010	2	
	Q0003-001	5	
	Q0003-002	6	
	Q0003-006	4	
Gilbarco	PA02591144000	24	1
	PA02592000000	8	
	PA02592000010	16	1
	PA0259300000-2	2	
Incon	TS-ILS	1	
	TSP-DIS	1	
	TSP-HIS	2	
	TSP-ULS	15	1
Mallory Controls	Pollulert FD 221GTRA	3	
	Pollulert MD 241RRA	6	1
Mine Safety Appliances	Tankgard 482607	5	2
Owens-Corning Tank	FHRB 810	1	
PermAlert	PSTV	1	
Pneumeractor	LS 600LD	3	
Red Jacket	RE400-111-5	6	
	RE400-203	6	
	Liquid Refraction (Unknown)	1	
	Unknown	1	
Ronan	LS-30	5	
	LS-3	59	4
	LS-7	18	
	Unknown	1	
Universal Sensors	LAVS-1	1	1
	LALS-1	29	2
	LS 03875 STP	3	
Veeder-Root	330212-001	7	
	331102-002	2	
	794380-208	171	3
	794380-209	3	
	794380-300	1	
	794380-301	3	
	794380-302	8	
	794380-320	2	
	794380-322	1	
	794380-341	26	11
	794380-350	39	4
	794380-352	52	1
	794380-408	4	
	794380-500	1	
	794390-205	40	
	794390-352	33	2
	794390-407	20	2
	794390-409	22	2
	794390-420	80	2
	794390-460	4	
	847990-001	6	
Warrick Controls	DLP-1-NC	2	1
Total		789	44

(Note: Veeder-Root and Gilbarco sensors are produced by the same manufacturer)

Table 3 - Sensors Failing to Alarm, by Manufacturer

Manufacturer	Sensors Tested	Failures	Failure Rate (%)
Alpha Wire	2	0	0
Beaudreau	25	3	12
Emco	17	0	0
Gilbarco	54	2	4
Incon	19	1	5
Mallory Controls	9	1	11
Mine Safety Appliances	5	2	40
Owens-Corning Tank	1	0	0
PermAlert	1	0	0
Pneumeractor	3	0	0
Red Jacket	14	0	0
Ronan	83	4	5
Universal Sensors and Devices	33	3	9
Veeder-Root	521	27	5
Warrick Controls	2	1	50
TOTAL	789	44	5.6

Table 4 - Sensors Failing to Alarm, by Operating Mechanism

Operating Mechanism	Sensors Tested	Failures	Failure Rate (%)
Conductivity	9	1	11
Float Switch	539	17	3
Float Switch, Product Permeable	97	3	3
Metal Oxide Semiconductor	1	1	100
Optical	39	3	8
Thermal Conductivity	37	4	11
Ultrasonic and Capacitance Change*	26	11	42
Ultrasonic and Product Permeable	41	4	10
Total	789	44	5.6

* All sensors in this category were Veeder-Root model 794380-341

Failure Rates, by Facility Ownership

The quality of installation and maintenance procedures at a UST facility is expected to affect sensor reliability. An assumption was made that the quality of maintenance and installation would vary depending on the type of facility ownership. Therefore, an attempt was made to gather and compare data from a variety of types of facility ownership. The distribution of sensors by facility ownership is shown in Table 5.

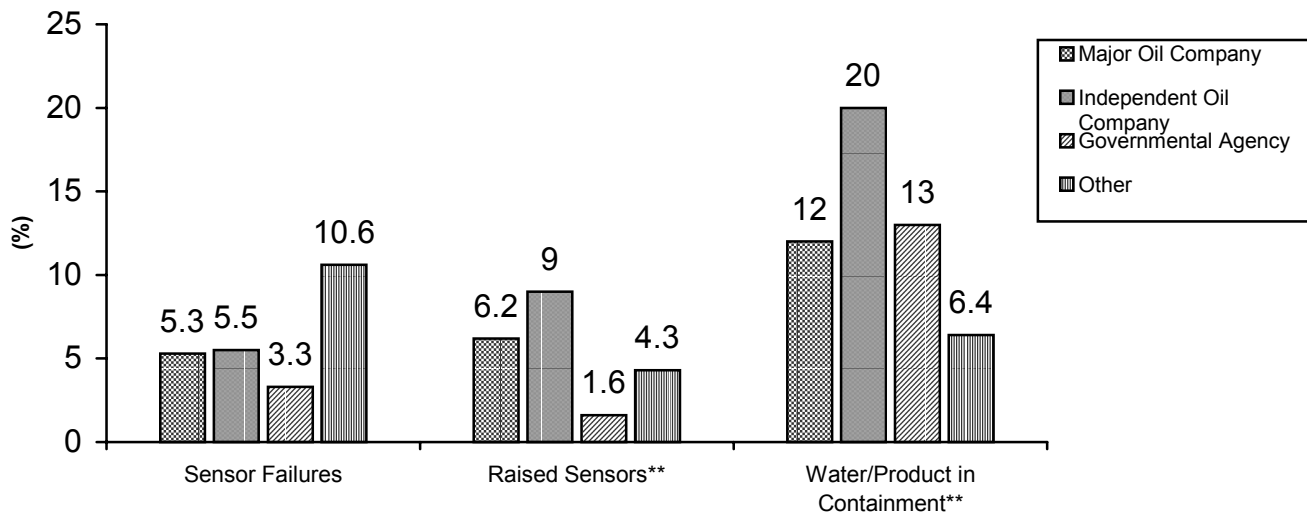
Table 5 - Number of Sensors Tested, by Facility Ownership

Ownership	# of Facilities	# of Sensors
Major Oil Company	76	504
Independent Oil Company	23	177
Governmental Agency	16	61
Other*	9	47
Total	124	789

* Other includes emergency generator fueling systems, chemical storage tanks, and fleet fueling facilities.

Field data shows that failure rates were similar among major oil and independent owners. Other facility ownership types had a failure rate of roughly twice that of the major and independent oil marketers, although the sample size for “other ownership” was somewhat limited. Independently owned facilities had a noticeably higher rate of raised sensors and water or product in the secondary containment. This may be attributed to less stringent construction standards, or less frequent visual inspection of the secondary containment. Sensor performance data by facility ownership is shown in Figure 5.

Figure 5 - Sensor Performance, by Facility Ownership



**Calculations based on the 722 sensors tested in Phase II, since data on raised sensors and water/product in the containment were not recorded in Phase I.

Performance of Discriminating Sensors Compared to Non-Discriminating Sensors

SWRCB staff have received many comments from inspectors and contractors, stating that discriminating sensors do not perform reliably in the field. Responses to the sensor survey echoed these comments. We targeted as many facilities with discriminating sensors as possible, collecting data on a total of 182 discriminating sensors, including the 67 tested during the Phase I. Of these 182 discriminating sensors, 132 were tested in both water and product. Figures 6a, 6b, and 6c show a comparison between discriminating sensors tested in water only, discriminating sensors tested in both water and product, and non-discriminating sensors.

Because the Veeder-Root model 794380-341 discriminating sensors have such high failure rates, and because Veeder-Root has since that time specified that all model 794380-341 sensors should be programmed as non-discriminating, the performance of discriminating sensors excluding the model 794380-341 have also been included for comparison.

Figure 6a - Number of Sensors Tested

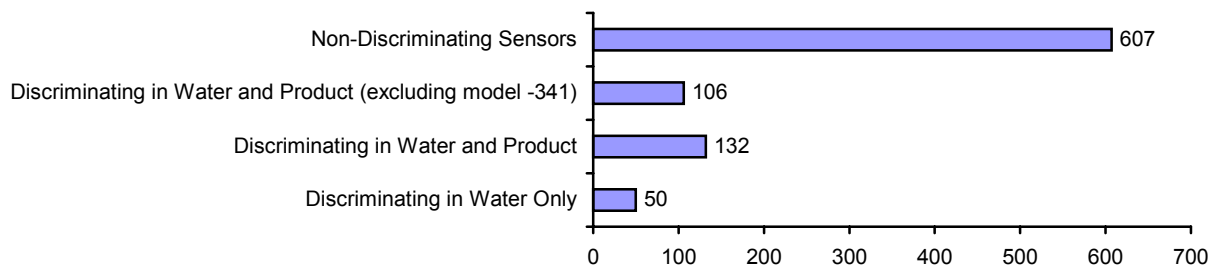


Figure 6b - Percentage of Sensors Failing to Alarm Properly When Tested

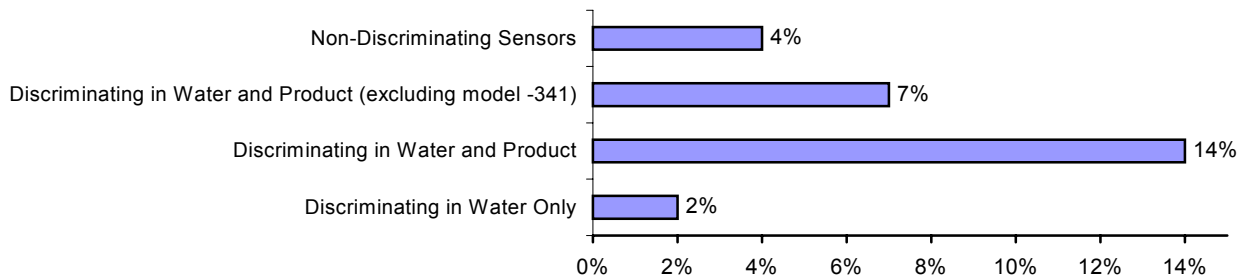
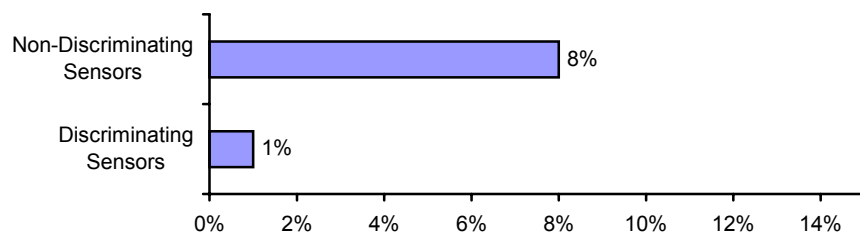


Figure 6c - Percentage of Sensors Not at Low Point



Field data shows that, when excluding the Veeder-Root model 794380-341 sensor, discriminating sensors failed to alarm properly only slightly more frequently than non-discriminating sensors. It is also important to note that discriminating sensors appear to be less likely to be raised from their proper location. In contrast to these findings, 77% of survey respondents stated that discriminating sensors were less reliable than non-discriminating sensors. This may be due to their negative experiences with the model 794380-341 sensor. It may also reflect the fact that our field data has an important limitation. Due to contractors' reluctance to test discriminating sensors in product³ and the difficulty in locating a wide selection of makes/models, many discriminating sensors were not tested in product. Without test data on more makes and models, and without the ability to test these sensors both in product and water, it is difficult to make a statistically valid statement regarding the relative reliability of discriminating versus non-discriminating sensors. Table 6 lists the failure rates for all discriminating sensors tested in product, sorted by make and model.

Table 6 - Performance Data for Discriminating Sensors, by Make and Model

Make	Model	# of Sensors Tested in Product	# of Failures when Tested in Product	Failure rate when Tested in Product (%)	# of Sensors Tested in Water Only	# of Failures when Tested in Water Only	Failure rate when Tested in Water Only (%)	Total # of Sensors Tested	Total # of Failures	Total Failure Rate (%)
Alpha Wire	Unknown	0	-	-	2	0	0	2	0	0
Emco Electronics	Q0003-001	0	-	-	5	0	0	5	0	0
	Q0003-002	0	-	-	6	0	0	6	0	0
Incon	TSP-DIS	0	-	-	1	0	0	1	0	0
Mallory Controls	Pollulert FD 221GTRA	3	0	0	0	-	-	3	0	0
	Pollulert MD 241RRA	6	1	17	0	-	-	6	1	17
Red Jacket	RE400-203	0	-	-	6	0	0	6	0	0
Veeder-Root	794380-320	2	0	0	0	-	-	2	0	0
	794380-322	0	-	-	1	0	0	1	0	0
	794380-341	26	11	42	0	-	-	26	11	42
	794380-350	39	4	10	0	-	-	39	4	10
	794380-352	56	2	4	29	1	3	85	3	4
Total		132	18	13.5	50	1	2	182	19	10
Total Excluding Model 794380-341		106	7	6.5	50	1	2	156	8	5

Determining the Reason for Sensor Failures

It is important to understand what causes failures of sensors in the field. However, the reasons are not always apparent. When possible, SWRCB staff and the technician performing the test attempted to determine the cause of failure. In cases where the cause of failure could not be determined, SWRCB staff followed up with the proper regulatory agency and/or service technician to verify that the failure was repaired and the system was verified functional.

³ Many contractors state that testing polymer strip discriminating sensors in product is impractical due to excessive response and recovery times. Further, some sensors may not recover after repeated or prolonged exposure to product, thus requiring replacement.

FINDINGS

The findings of this report have been sorted into six general categories: *Sensor Design and Performance*, *Secondary Containment Performance and Compliance Issues*, *Oversight and Qualifications*, *Sensor Field-Certification and Testing Procedures*, *Maintenance and Programming*, and *Discriminating Sensors*. These categories reflect the fact that the condition of secondary containment, the frequency and quality of maintenance and testing, the level of training among operators and service technicians, and the quality of regulatory oversight will all impact the effectiveness of sensors as a leak detection method. The *Sensor Design and Performance* section contains findings applicable to all sensors, while findings pertaining specifically to discriminating sensors have been included as a separate section for easy reference. A section covering *Other facility Observations Not Relating to Sensors* has also been included. However, there is only limited discussion on these observations, since they are beyond the scope of this field evaluation.

A. Sensor Design and Performance

- 1. Observation:** Sensors failed to alarm properly for 5.6% of sensors tested (44 out of 789)⁴. A list of sensor failures, by make and model, is included in Appendix VI.

Likely Cause: Causes varied, but failures are either due to defects in the sensors themselves, or defective/corroded wiring between the sensor and the control panel.

Consequences: Sensors failing to alarm when tested would likely also fail to alarm in the event of a leak, leading to an increased risk of release to the environment.
- 2. Observation:** Sensors can corrode over time. Corrosion interferes with sensor performance in a variety of ways. A common form of corrosion was observed with Veeder-Root 794380-420 float switch sensors installed in the interstitial space of double-walled steel tanks. These sensors have steel housings, which were frequently observed to be cracked. Corrosion can also affect the internal components of a sensor. The field evaluation showed that the moving parts of float switches could become lodged in place due to corrosion. In rare instances, the float had fallen off due to corrosion of the pin that holds the float in place.

Likely Cause: Materials used in the manufacture of sensors are not always compatible with the stored substances, moisture, and materials found in the secondary containment of UST systems.

Consequences: Since there is limited space in the interstice of steel tanks, a cracked sensor casing can make it impossible to remove the sensor for testing. Technicians have said that such sensors occasionally have to be abandoned in the tank interstice, with new sensors installed above them. Corrosion of internal sensor components can result in missed detection of product in the secondary containment.
- 3. Observation:** Interstitial sensors in double-walled fiberglass tanks can become lodged between the inner and outer tank walls.

⁴ This value includes 2 float switch sensors that were in water within the sump prior to testing, but were not in alarm. Although these sensors eventually alarmed when shaken vigorously, they were recorded as failures.

Likely Cause: Sensors are designed to be inserted into a small channel and wrapped around the tank, so that the sensor rests at the low point of the interstice. A pull string is used to position the sensor into the proper position within the tightly confined tank interstice. In some instances, the sensor becomes lodged. Several technicians commented that this might be due to the inner tank settling under the weight of the product stored, effectively pinching the sensor between the inner and outer walls.

Consequences: When a sensor becomes lodged in the interstitial space, it cannot be removed for testing. If sensors cannot be removed for testing, their functionality cannot be verified. Without verifying functionality, a faulty sensor could go undetected, leaving the secondary containment unmonitored. Further, installation of a new sensor is impractical, since the same physical barrier preventing removal of the old sensor will also prevent proper installation of a replacement sensor.

4. **Observation:** Float switches that alarm when tested may not alarm under leak conditions. At two facilities with float switch sensors, a sensor was sitting in sufficient liquid within a sump to activate an alarm, but was not in alarm. Another two facilities had sensors with stuck floats. The sensors went into alarm once the technician removed and shook them vigorously.

Likely Cause: When inspecting turbine sumps, staff discovered that movement of some floats was hindered by debris, preventing the alarm from being activated until a technician removed and shook the sensor.

Consequences: Sensors that do not go into alarm because floats are lodged by debris can result in missed detection of product in the secondary containment.

5. **Observation:** Sensors failing to activate alarms when immersed in liquid was observed at several stations.

Likely Cause: The leading cause appeared to be faulty wiring, which was either installed incorrectly or had degraded over time. Another cause was faulty sensors. At one facility, three of four Beaudreau model 406 sensors installed within the under-dispenser containment failed due to faulty dispenser cut-offs, (similar to a control panel, but designed to cut power to the dispenser when the sensor detects liquid).

Consequences: Sensors failing to activate alarms when immersed in liquid can result in missed detection of product in the secondary containment.

6. **Observation:** At two facilities in the field evaluation, sensors activated alarms when tested but did not come out of alarm.

Likely Cause: While further follow-up is required to determine the exact cause, technicians at the facility suspected a short in the wiring between the sensor and the control panel.

Consequences: Leak detection equipment malfunctioning in this manner needs immediate service. Facilities with pump shutdown will be out of service until the problem is fixed. At facilities without pump shutdown, an operator may choose to ignore the alarm. This leaves the monitored area with no leak detection, and, therefore, poses a risk of release.

B. Secondary Containment Performance and Compliance Issues

1. **Observation:** Approximately 6.5% of sensors tested (46 of 722) were not properly located at the lowest point of the secondary containment⁵. For the purposes of this field evaluation, sensors were recorded as “not at lowest point” if they appeared to have intentionally been raised from their proper location, or if they could not be placed in the proper location due to insufficient length of wiring or a similar reason.

Likely Cause: In some cases, facility operators may have been raising sensors to avoid having to respond to frequent alarms caused by surface water and/or ground water ingress into the secondary containment. In other cases, the design of the secondary containment may have made it difficult to place the sensor in the proper location, since other components may be in the way. Sumps that have a designated location for mounting the sensor (such as a pipe mounted to the sump wall) reduced the likelihood of raised sensors.

Consequences: California regulations state that sensors should be able to detect leaks at the earliest possible opportunity⁶. Raised sensors are unable to detect liquid in the secondary containment at the earliest opportunity, placing the facility out of regulatory compliance and increasing the threat of a release to the environment. By raising sensors, facility owners and operators may also be subject to penalties for tampering with monitoring equipment.

2. **Observation:** Water ingress into at least one portion of the secondary containment occurred at 31% of facilities (33 of 106) tested in Phase II. Water ingress was most common in tank-top sumps; 18% (64 of 353) contained water. Water ingress was observed only occasionally in the tank interstice and under-dispenser containment. In 22 of the 75 cases where water was present in the secondary containment, the sensor was raised to prevent alarm. The depth of water in the secondary containment varied from less than one inch to almost two feet.

Likely Cause: Construction of some secondary containment systems allows surface water ingress. Groundwater may also be entering into improperly constructed secondary containment.

Consequences: Water in the secondary containment leads to alarms, which may prompt the UST operator to raise or disable the sensors. Water also occupies volume in the secondary containment, reducing its ability to contain product in the event of a release from the primary containment. Further, water may accelerate deterioration of UST components and leak detection equipment since they are not generally designed to be wet for an extended period of time.

3. **Observation:** 11% of facilities (12 of 106) tested in Phase II had product present in at least one portion of the secondary containment. The presence of product was most common in tank-top sumps, where nearly 7% (24 of 353) contained product. Waste oil tanks often contained product in fill sumps. The depth of product varied from less than 1 inch to approximately 18 inches.

Likely Cause: Releases from primary containment will collect in the secondary containment. In turbine sumps, the apparent cause of most leaks was faulty seals within the pump heads. Diesel fuel was observed most often, likely due to its slow evaporation rate. Careless filling practices are the most likely cause of product in fill sumps.

⁵ Calculations based on the 722 sensors tested in Phase II only, since this information was not recorded in Phase I.

⁶ California Code of Regulations, Title 23, Section 2630(d)

Consequences: Product in the secondary containment poses a significant fire hazard, as well as an increased risk of release to the environment.

4. **Observation:** Monitoring systems at 2 of the 106 facilities tested in Phase II were in alarm when the service technician arrived to conduct testing. The staff on-site had not taken action in response to these alarms.

Likely Cause: UST operators may not have been trained in the proper response to alarms. Repeated false alarms may lead operators to ignore them, believing that proper alarm response is not important.

Consequences: Failure to respond to alarms leads to an increased risk of release to the environment.

5. **Observation:** Some sensors are being used in applications for which they have not been designed. Sensors were used to monitor products for which they are not certified, such as solvents, caustic chemicals, and waste oil. In one case, an interstitial sensor intended for use in a steel tank had been installed in a fiberglass tank.

Likely Cause: Inadequate training of inspectors and installers plays a likely role in the improper application of sensors. Inspectors and contractors may not know that a sensor designed for use in unleaded fuel may not be effective in waste oil or certain chemicals.

Consequences: Sensors used with incompatible products may deteriorate more quickly, or be unable to detect a release from the primary containment. A steel tank sensor is not designed to fit within the interstice of a fiberglass tank. Steel tank sensors must operate in a vertical position, but a fiberglass tank interstice is designed to be monitored with a sensor that is installed horizontally. Sensors used in applications for which they have not been designed may not reliably detect a release from the primary containment.

6. **Observation:** Degradation of the tank interstice made it impossible to remove/test sensors in some fiberglass tanks. It is often difficult (and sometimes impossible) to remove sensors from the annular space of fiberglass tanks for inspection/testing.

Likely Cause: The pull-string used to install and remove sensors from the tank interstice was often missing or broken, making it difficult for technicians to replace the sensors once they were removed. The primary tank tends to settle within the secondary tank over time, effectively pinching the sensor between the walls of the primary and secondary containment.

Consequences: When sensors cannot be tested, it is impossible to verify that they are functioning properly. For sensors that are removed but cannot be replaced, the tank interstice is not monitored.

C. Oversight and Qualifications

1. **Observation:** Inspectors were present for observation and data collection at 79 of the 106 of facilities evaluated in Phase II (75%). This rate of participation was higher than average due to interest in the field evaluation, and the fact that the inspectors had assisted SWRCB staff in coordinating inspections. The rate of inspector oversight during annual monitoring equipment testing and certification is generally lower.

Likely Cause: The regulatory agency's resources do not always allow inspectors to oversee monitoring equipment certifications at every facility in their jurisdictions. Furthermore, it may be difficult to coordinate the inspection with the technician conducting the certification.

Consequences: Coordination of annual facility inspection and the monitoring certification allows inspectors to visually inspect sensor locations, and to verify that technicians are conducting the monitoring certification properly. Problems noted by an inspector can often be remedied immediately, using the skills of the service technician already present. These benefits are lost if inspection and monitoring certification are not performed simultaneously.

2. **Observation:** A wide range of knowledge and experience with sensors was observed among technicians and inspectors. Technicians had experience working in the UST field ranging from a few months to over 25 years.

Likely Cause: The level of knowledge seems directly related to experience. Inspectors and technicians that are new to the UST field are not as knowledgeable about the regulations and equipment as those with many years of experience. Inspector expertise may also depend on the structure of the regulatory agency. Some agencies have inspectors dedicated exclusively to the UST program, while other agencies cross-train inspectors in a variety of programs.

Consequences: Inspectors and service technicians play a key role in ensuring that a UST facility is properly maintained and regulated. Lack of proper training for the inspector or service technician increases the likelihood of non-compliant or substandard UST systems remaining in operation. Such systems may pose an increased risk of release to the environment.

3. **Observation:** Some technicians performing annual certification of monitoring equipment do not repair or replace faulty sensors at the time of testing. Regulatory agencies may specify that sensors be repaired or replaced within a specified amount of time, generally 30 days.

Likely Cause: Some technicians who conduct the annual certification of monitoring equipment do not have contracts specifying that they perform repairs. Their responsibility is to test the equipment and report on its functionality. In other cases technicians may have contracts to perform repairs as needed, but do not have the necessary replacement parts or diagnostic equipment.

Consequences: Facilities may be allowed to operate without functional monitoring equipment for 30 days or longer while repairs are scheduled and completed.

D. Sensor Field-Certification and Testing Procedures

1. **Observation:** Float switch sensors are often tested by flipping them rather than immersing them in liquid. Some sensors that had been immersed in water without activating an alarm were found to activate an alarm when flipped.

Likely Cause: Flipping or shaking a float switch sensor can free up a float that may be clogged by dirt or debris. Some technicians believe that immersing the sensor in water during testing promotes corrosion, thus reducing the effective life of the sensor.

Consequences: Manually flipping a float switch sensor is an effective method of activating an alarm condition, and verifying that monitoring system responds accordingly. However, flipping a sensor over does not accurately simulate the conditions a sensor encounters in the event of a leak.

2. **Observation:** Under-dispenser containment (UDC) boxes with mechanical floats and chains (i.e. Bravo Boxes) are not commonly tested. The inspector required functional testing of the float-and-chain UDC leak detection device at only one of the 106 facilities tested in Phase II, and no test results were recorded or included in our database. Occasionally during this field evaluation, inspectors looked to see that the chains were connected. According to the few inspectors who routinely require testing of float-and-chain UDC leak detection devices, the failure rate is high.

Likely Cause: The common reasons given by service technicians and inspectors for not testing these sensors is that the process takes too long or is too difficult.

Consequences: Without periodic testing, faulty equipment may go unnoticed. This equipment may not function properly in the event of a leak from the primary containment, leading to an increased risk of release. Additionally, undetected releases from primary containment may accumulate in secondary containment and pose a significant risk of fire, particularly in the UDC.

3. **Observation:** Old equipment is still in use at a number of facilities, even though the manufacturers are out of business or no longer support the product.

Likely Cause: As long as their old leak detection equipment continues to function and is in compliance with regulatory requirements, there is no incentive for an owner to replace these devices.

Consequences: Although this equipment may still be functioning, it poses a number of potential problems. Technicians may not be familiar with operation and testing procedures for obsolete systems. If the manufacturer is no longer in business, there is generally no service technician training available. Technicians may also be hesitant to test equipment for which replacement parts are unavailable.

4. **Observation:** Test procedures are inconsistent. Procedures vary from one contractor to the next and from one regulatory agency jurisdiction to the next. For example, some technicians tested float switch sensors by inverting them, while others dipped them in water. Some thermal conductivity sensors were tested in liquid, while other technicians blew on the sensor to activate an alarm.

Likely Cause: Many manufacturers do not provide detailed step-by-step field testing procedures and training. Some technicians may not have received training from manufacturers on field testing procedures. In addition, some inspectors may not believe that manufacturers' procedures are adequate and may require sensors be tested in a way other than that recommended by the manufacturer.

Consequences: Without standard testing procedures, the possibility exists that inadequate procedures may be used. In such cases, there is no assurance that the sensors would reliably detect releases from the primary containment.

E. Maintenance and Programming

1. **Observation:** The pump shutdown (PSD) feature is not always functional. Additionally, we observed a wide range of pump shutdown response times. Times ranged from nearly instantaneous to several minutes.

Likely Cause: Technicians in the field attribute PSD failure to sticky relays. Factors affecting shutdown time include control panel model, software version (particularly with the Veeder-Root/Gilbarco panels), and complexity of leak detection equipment at the facility. (For example, the more sensors at a facility, the slower the shutdown).

Consequences: Pump shutdown failure could result in piping sumps or under-dispenser containment overflowing in the event of a catastrophic piping failure.

2. **Observation:** In many instances, a console had not been programmed according to the facility monitoring plan.

Likely Cause: Many monitoring equipment manufacturers provide the user with a variety of set-up and alarm options for their facilities. These options include activating pump shutdown, indicating a warning instead of an alarm, or dialing out to a remote location in the event of an alarm condition. In cases where the console set-up did not match the monitoring plan, it is possible that the console was not programmed correctly at the time of installation. Programming may also have been changed, intentionally or inadvertently, either at the console or remotely via a modem connection.

Consequences: Programming of the monitoring console affects sensor performance and the ability to properly alert an operator in the event of a problem. Improper programming may also place a facility out of regulatory compliance.

F. Discriminating Sensors

1. **Observation:** Although field staff requested that discriminating sensors be tested in water and product, this was only done 56% of the time (65 of 115 discriminating sensors)⁷.

Likely Cause: Many technicians and inspectors are hesitant to test discriminating sensors in product due to the long response and recovery times. There is also a concern that the sensors may not recover after being exposed to product, and will have to be replaced.

Consequences: Unless a discriminating sensor is tested in product, the functionality of one of its operating modes is not verified. Since the sensor's full performance is not determined, there is an increased possibility of missed detection.

2. **Observation:** Many of the Veeder-Root 794380-341 sensors (shown in Figure 8) exposed to product indicated a water alarm. This problem was observed in 13 of 26 model 794380-341 sensors in the first phase of testing, and 9 of 17 in the second phase. Overall, the model 794380-341 sensor failed to alarm properly approximately 50% of the time.

Likely Cause: Since this problem is specific to the model 794380-341 sensor, there is likely a design or manufacturing flaw.

Consequences: UST owners and operators generally consider response to water less urgent response than product alarms. Therefore, product in the interstitial space that is falsely identified by the sensor as water may pose an increased risk of release to the environment.

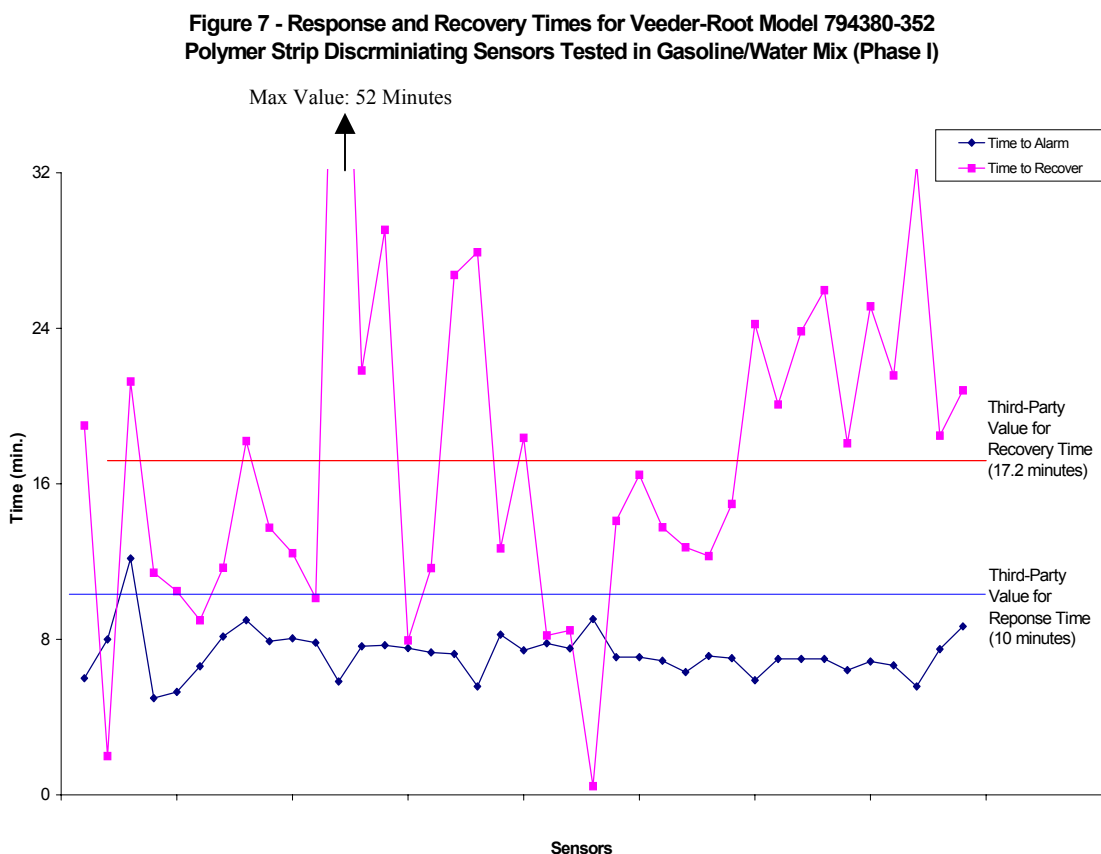
3. **Observation:** Response and recovery times of the polymer strip element when exposed to fuel were sometimes excessive, and not always consistent with third-party claims. Response times in a gasoline/water mixture ranged from 5 to 12 minutes, with an average of

⁷ Does not include sensors tested during Phase I, since testing in product was mandated during that phase.

approximately 7 minutes. Recovery times in gasoline ranged from 1 minute to over 50 minutes, with an average of approximately 17 minutes (see Figure 7).⁸

Likely Cause: The fuel alarm is activated only after enough fuel has permeated the polymer strip to raise its electrical resistance to a set value. Typically the resistance in the strip did not begin to change appreciably for several minutes.

Consequences: A primary concern with polymer strip discriminating sensors is the amount of time they take to alarm. In the event of a catastrophic leak from pressurized piping, the slow response time could allow for a large release of fuel into the UDC or containment sump before the alarm sounds. When the liquid level reaches the high-level liquid set point, a high-level water alarm will sound. It could still be many minutes before the polymer strip reacts to the fuel and activates a fuel alarm. This could be a major concern if the system is not configured for turbine shutdown when the high-level water alarm is activated. An additional concern is the wide variation in response times from one sensor to another. With such variation, it is difficult to determine exactly how long a polymer-strip sensor should typically take to alarm once exposed to fuel, to establish field-testing guidelines, or to determine if a sensor is actually non-functional or just slow to respond.



⁸ A thorough discussion on response and recovery of polymer strip discriminating sensors can be found in the "Summary of Test Results from Phase I Testing," which is included in Appendix I.

4. **Observation:** Current third-party protocols may not be appropriate for polymer-strip sensors. **Likely Cause:** Third-party evaluators have been using a standard liquid point detection protocol to evaluate polymer-strip sensors. These protocols are designed for mechanical or electrical switching devices that do not use chemical reactions like the polymer strips. The protocol does not take into account factors that may affect polymer-strip sensors. The ability to alarm and recover in a variety of environmental conditions is not assessed. The impact on response time and recovery time after repeated fuel exposure of these sensors is not evaluated. **Consequences:** Sensors may fail to detect a product release in the field, not respond quickly under certain conditions, and not recover once exposed to product.
5. **Observation:** Some discriminating sensors may not be able to detect product floating on water. **Likely Cause:** Hydrocarbons typically float on water, and most discriminating sensor designs require the sensor to be in contact with product in order to detect it. Therefore, some discriminating sensors will not detect product release when sufficient water is present. The level of water that will result in a missed detection varies depending on sensor design. Designs can be divided into two general categories: Point Liquid Type and Polymer Strip Type. Each of these categories has distinct capabilities and limitations, as described in Appendix VII. **Consequences:** Sensors may not detect a product release when water is present in the secondary containment, which may pose an increased risk of release to the environment.

G. Other Observations Not Relating to Sensors

The following observations do not directly relate to the effectiveness of sensors as a method of leak detection, but are compliance related items that pose an increased environmental risk. Discussion of these observations is limited because they are beyond the scope of this field evaluation, but follow-up and enforcement action may be appropriate.

1. Line leak detectors (LLDs) have a high failure rate when tested with a 3.0 gallons per hour at 10 pounds per square inch leak rate. All staff collecting data for this field evaluation observed failures, although LLD failure data were not recorded. In general, mechanical LLDs failed more frequently than electronic LLDs. SWRCB staff are currently evaluating the effectiveness of LLDs in the field as part of a separate project.
2. Some UST facilities had recently installed under-dispenser containment (UDC), but did not install monitoring devices as required by California regulations⁹. In one case, a small leak from the dispenser piping had resulted in nearly 18 inches of diesel fuel in the UDC. In this case, it appeared that the presence of UDC prevented a release to the environment. However, the leak had gone undetected for some unknown time period, and would have remained undetected if the annual facility compliance inspection were not being performed that day.
3. The overfill prevention devices had been tampered with at one facility. Long sticks had been inserted and left in the fill pipes, effectively disabling the fill tube positive overfill protection device. Comments from technicians and inspectors indicate that this is not uncommon.

⁹ California Code of Regulations, Title 23, Section 2636(f)

RECOMMENDATIONS

The following recommendations are designed to improve the effectiveness of sensors as a leak detection method by addressing specific issues observed during this field evaluation. Just like the “findings” section of this report, recommendations are organized into six categories: *Sensor Design and Performance*, *Secondary Containment Performance and Compliance Issues*, *Oversight and Qualifications*, *Sensor Field-Certification and Testing Procedures*, *Maintenance and Programming*, and *Discriminating Sensors*. The *Sensor Design and Performance* section contains recommendations applicable to all sensors, while issues pertaining specifically to discriminating sensors have been included as a separate section for easy reference. Note that no specific recommendations have been made to address the findings listed under *Other Facility Observations Not Relating to Sensors*, since these are beyond the scope of work for this report.

A. Sensor Design and Performance

- **Improvement in the design and manufacture of sensors is needed.** The results of this field evaluation indicate that the environment in which UST leak detection sensors operate can degrade their performance over time. Manufacturers should design sensor housings, wiring, and functional elements to endure UST system conditions for the anticipated life of the sensor.
- **Float switch sensor design should allow for free movement of the float.** For a float switch sensor to operate effectively, the float must be free to move up and down in response to the presence of liquid in the secondary containment. Manufacturers should produce float switch sensors that are not easily obstructed by dirt and debris, or are in an enclosed housing that keeps debris away from the float mechanism.
- **All sensors should be evaluated under field-representative conditions.** Standard U.S. EPA evaluation protocols should be re-evaluated by a workgroup of inspectors, manufacturers, and third-party evaluators. Modifications to the protocols should be made to assure that the evaluation challenges the sensor’s performance under conditions likely to be encountered in the field. Once the new protocol is in place, only sensors that have been evaluated by an independent third party in accordance with the revised protocol should be approved for new installations.
- **Sensors should not be used as the sole method of leak detection for double-walled pressurized piping.** This field evaluation has shown that, for a variety of reasons, sensors may fail to detect a release from the primary containment. Therefore, a line leak detector or other leak detection should be used as a backup. This will reduce the risk of release to the environment in the event of a catastrophic failure of the primary piping.

B. Secondary Containment Performance and Compliance Issues

- **Secondary containment should be designed and constructed to prevent the ingress of surface and ground water.** Preventing water ingress will reduce the frequency of water alarms from sensors in the secondary containment. It will also help reduce the tendency of facility operators to raise their sensors to avoid water alarms, and would reduce the amount of water that has to be removed from the containment and disposed of properly. Finally, any adverse impact that water may have on sensors (such as corrosion or accelerated failure of internal components) would be minimized by keeping water out of the secondary containment.
- **Secondary containment should be tested periodically.** Testing will verify that the containment is capable of holding product in the event of a release. Testing will also identify points where groundwater may enter the containment. Once identified, these points can be repaired in order to prevent groundwater intrusion into the secondary containment.

C. Oversight and Qualifications

- **UST operators should be trained about their role in effective leak prevention.** The most common problem observed in this field evaluation was raised sensors. In many of these cases it is likely that the facility operator raised the sensor in order to disable it, or to take it out of alarm when liquid was in the secondary containment. Tampering with leak detection is a regulatory violation, and individuals caught doing so may be subject to penalties and fines. Raising sensors makes the leak detection system less effective, thus increasing the risk of release of hazardous substances to the environment. Training UST owners and operators on proper alarm response and the consequences of tampering with monitoring equipment will help reduce this problem.
- **Enforcement action should be taken against those who intentionally hinder the effectiveness of leak detection equipment.** This includes tampering with sensors, ignoring alarms, turning off monitoring systems, or failing to take action when product or water is present within secondary containment. Enforcement action may also be appropriate for other violations that increase the risk of release to the environment, such as tampering with overfill prevention equipment.
- **UST inspectors would benefit from additional training on the limitations and proper application of sensors.** Some sensors were installed incorrectly for the specific conditions at a particular UST facility. Facility-specific conditions included the type of product stored and the size or shape of the monitored space. By better understanding how each type of sensor operates, regulators can make more informed decisions about the appropriate application and placement of specific sensors when reviewing and approving monitoring plans.

D. Sensor Field-Certification and Testing Procedures

- **All sensors should be functionally tested at least annually.** This annual testing should include under-dispenser containment boxes with mechanical floats and chains (i.e. Bravo Boxes). Testing procedures should also include verification of alarms and pump shutdown where applicable. Monitoring systems that provide shutdown of the pumping system when sensors are disconnected and/or when the monitoring system loses power should also be functionally tested.
- **Testing should be conducted by a qualified service person.** Service technicians should be knowledgeable about UST monitoring systems, and should be trained the manufacturers of the equipment they are working with. Periodic testing should verify functionality of the sensor, and should be conducted in accordance with the manufacturer's recommended protocols, in a manner consistent with all applicable regulations.
- **A standard field test procedure should be developed for each sensor technology.** The procedures should demonstrate each sensor's ability to reliably detect a leak (for example, float switch sensors should be tested in liquid rather than by flipping). Manufacturers should work with technicians and regulators to develop these testing procedures, and should train service technicians to perform the testing properly. Technicians should be required to conduct testing in accordance with standard procedures once such procedures are in place.

E. Maintenance and Programming

- **Secondary containment should be inspected frequently to verify that it is clean and free of liquid (water and product) and debris.** This field evaluation showed that, due to a variety of factors, sensors were not 100% effective at detecting liquid in secondary containment. Therefore, it is important to perform frequent visual inspection of these areas. We recommend that visual inspections be conducted on at least a monthly basis.
- **Float sensors should be inspected frequently (more than once a year) to verify that they are functional.** Float sensors may not work properly if debris and dirt within the secondary containment interferes with the movement of the float mechanism. In order to have effective monitoring of secondary containment using float sensors, frequent inspections and maintenance is important. This recommendation is particularly significant given the prevalence of float sensors (68% of sensors in this field evaluation).
- **Sensors installed in piping sumps to monitor pressurized piping should be programmed to shut down the pump when product is detected.** Most monitoring systems are capable of this function if they are programmed accordingly. Programming the monitoring system to shut down the pump when a leak is detected in the piping is a simple, inexpensive way to reduce the risk of release of hazardous substances to the environment.

F. Discriminating Sensors

- **Veeder-Root model 794380-341 sensors should not be used as discriminating sensors.** The field testing demonstrated they are unable to discriminate between water and product nearly half of the time. However, they were able to reliably determine the presence of liquid. Therefore, all alarms from the model 794380-341 sensors, whether water or product, should be treated identically. Consoles should be programmed accordingly, and Veeder-Root has issued a statement to this effect. We further recommend that all model 794380-341 sensors that fail the annual monitoring certification be replaced with a different model.
- **Discriminating sensors should be tested in water and product as part of the annual monitoring certification.** Since discriminating sensors are programmed to respond differently in product than in water, and since different alarms may receive different responses from on-site staff, it is important to verify that the water and product detection capabilities of the sensor are functional. If long response and recovery times make such testing impracticable, the use of a different type of sensor should be considered.
- **A new evaluation protocol should be developed to effectively evaluate polymer strip sensors¹⁰ under field-representative conditions that may impact their performance.** The protocol should assess the sensor's ability to respond to hydrocarbons in a variety of environmental conditions, and the impact that repeated/prolonged exposure to product may have on the sensor's ability to alarm and recover from alarm reliably. Since current evaluation protocols do not cover these key performance factors, no new polymer strip sensors should be installed until new evaluation protocols are in place and the sensors have been certified in accordance with those protocols.
- **Water alarms from point liquid discriminating sensors should receive a rapid response.** Since point liquid discriminating sensors can only respond to the liquid directly in contact with the detection element, they are unable to detect a product release floating on an existing pool of water whose height exceeds the level of the detection element. To minimize the risk of missed product detection with these sensors, it is important that water alarms be responded to promptly and owners and operators be trained on the limitations of these type of discriminating sensors. Regulatory agencies should consider the limitations of these sensors when reviewing monitoring plans.
- **When installed in turbine sumps and UDC, polymer strip discriminating sensors with low and high level liquid alarms should activate pump shutdown for both product and high-level liquid alarm.** Once the water level has risen above the high-level float, floating product will not come in contact with the polymer cable or strip. There is essentially no leak detection once water reaches the high-level float, so all sensors of this type which are monitoring pressurized piping should be programmed to shutdown the pump at high liquid level. Proper console configuration and operation of the pump shutdown feature should be verified during the annual monitoring certification.

¹⁰ See Appendix VII for a description of polymer strip and point liquid sensors.

- **Longer response times associated with polymer strip discriminating sensors may make them inappropriate for use in certain applications.** Polymer strip discriminating sensors are much slower to respond to hydrocarbons than other sensor types. Therefore, care must be taken when considering their use. Polymer strip discriminating sensors should not be used as the sole monitoring method for double-walled pressurized piping unless they are programmed to shut down the pump when exposed to water or product.
- **Polymer strip discriminating sensors should not be used in UST systems storing diesel.** Since diesel fuel is not as volatile as unleaded fuel, polymer strips respond much more slowly (response times in diesel fuel may be 12 hours or more.) The lengthy response time of polymer-strip sensors in diesel fuel poses an increased risk of release to the environment.
- **Monitoring plans for facilities with discriminating sensors should include response plans for both water and product alarms.** Leaving water in the secondary containment for an extended time period is unacceptable. The most appropriate solution for dealing with water in the secondary containment is to make the containment systems water tight. California's program of periodic integrity testing of secondary containment systems should help minimize water intrusion problems, by identifying and repairing leaks through which groundwater may enter. Regulatory agencies should review response plans to assure that response times for water and product alarms are appropriate based on facility-specific conditions.
- **Discriminating sensors may be reprogrammed as non-discriminating if needed.** In response to the recommendations of this report, or to comply with local ordinances, UST operators may wish to replace their discriminating sensors with a non-discriminating model. As an alternative to replacement, many discriminating sensors can be reprogrammed to operate as non-discriminating. Reprogramming can be a cost-effective solution for discriminating sensors that may not be providing effective leak detection or satisfying local ordinances. Note that only a representative authorized by the manufacturer should perform this reprogramming.

CONCLUSION

The results of this field evaluation indicate that sensors can be an effective form of leak detection only when properly installed, programmed, and maintained. Improper operation, poor installation and maintenance practices, deficiencies in the construction of secondary containment, and poor design of some sensors was observed during the field evaluation. When including instances of water or product in the secondary containment, raised sensors, ignored alarms, and failure of the pump shutdown feature, 12% of the sensors tested had a problem. The problems identified may well be even more common in states not requiring annual certification of monitoring equipment.

To make sensors a more effective form of leak detection, improvements are needed in the following areas:

Functionality of Sensors

- Manufacturers should consider improving sensor design and materials to make them more durable. Sensors should be designed and manufactured to operate under the conditions present at operating UST facilities.
- Sensors should not be used as the sole form of monitoring for double-walled pressurized piping. Line leak detectors should be required as additional protection, to reduce the risk of release to the environment in the event of a catastrophic release from the primary piping.
- Polymer strip discriminating sensors should not be used to monitor for the presence of less volatile hydrocarbons, such as diesel and waste oil.

Field Testing Procedures

- Periodic functional testing of sensors is critical to their effectiveness. Functional testing should be performed at least on an annual basis. However, more frequent visual inspection and preventative maintenance is recommended for all float switch sensors.
- Manufacturers should develop standard field testing procedures, and technicians should be trained on how to conduct field testing properly. Once test procedures are in place, technicians should be required to follow them. Test procedures should demonstrate a sensor's ability to detect a release (for example: testing in liquid for float switch sensors, and testing in both water and product for discriminating sensors).

Third-Party Evaluation of Sensors

- Current third-party certification test protocols for sensors should be modified to better and more thoroughly evaluate sensors, and subject them to the parameters present at operating UST facilities.

Regulatory and Technical Oversight

- Training is needed for UST owners, operators, installers, service technicians, and inspectors. Training should cover proper application, installation, testing, programming, and operation of sensors, as applicable.

- Enforcement action should be taken against those who tamper with sensors, ignore alarms, turn off monitors, or fail to take action where product or water is present within secondary containment.

Design and Construction of Secondary Containment

- Secondary containment should be designed, installed, and maintained to be water tight. This will help reduce the frequency of raised sensors and water alarms, and help prevent deterioration of the sensors and secondary containment.
- Secondary containment should be tested periodically. Periodic testing will help assure that secondary containment can prevent groundwater ingress and contain product in the event of a leak.



Winston H. Hickox
*Secretary for
Environmental
Protection*



Gray Davis
Governor

FIELD EVALUATION OF UNDERGROUND STORAGE TANK SYSTEM LEAK DETECTION SENSORS

- Appendices -

August 2002

**State Water Resources Control Board
Underground Storage Tank Program**

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APPENDIX I

Summary of Phase I Testing (Veeder-Root Discriminating Sensors)

Phase I Testing Summary

(Field Evaluation of Veeder-Root Discriminating Sensors)

Introduction

Sensors are used in a variety of places within a UST system to detect a release of product. For double-wall systems, they are either located inside the secondary containment (sumps and under dispenser pans) or in the space between the primary and secondary containment of the tank or piping, known as the interstitial space. Field experience has shown that due to numerous design, installation, and maintenance issues these areas are often not kept clean of water intrusion or excessive condensation. This has led the industry to introduce sensors that are capable of differentiating between water and hydrocarbons. These sensors are referred to as “discriminating sensors.”

Discriminating sensors can provide distinct alarms for water or product. Some even offer distinct alarms for low and high levels of water. Depending on how the control panel is programmed, a product or water (low or high level) detection can activate a warning, alarm, or pump shutdown. Typically, sensors are programmed to provide a warning when water is detected, which still allows the UST system to operate. Product detection is typically programmed to activate a fuel alarm, and may also automatically shut down the pump.

There are two basic approaches to discriminating sensors, as described in the following paragraphs. One approach to discriminating sensors is to combine two or more sensing elements into a single unit (See Figure I). This approach is well suited for sumps where surface water is prone to leak in, presenting the possibility of product floating on water. Sensing elements (most often a float switch) are used to detect low and high liquid levels. If the level rises above a preset point, the sensor notifies the operator by activating an alarm or warning message on a control panel. A hydrocarbon-sensing element (such as a product permeability sensor) is also incorporated to detect the presence of product. The combination of these multiple sensing elements into a single unit makes a discriminating sensor able to determine the presence of water versus hydrocarbons. There are several combinations of detection mechanisms that may be incorporated in a single unit to produce a discriminating sensor.

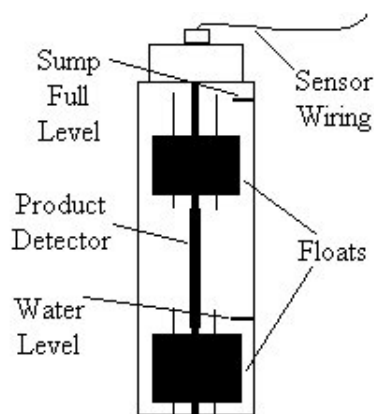


Figure I - A typical multi-element discriminating sensor with float switches and a product solubility element.

The second type of discriminating sensor uses only one detection mechanism, but is able to discern between product and other liquids based on some specific property of the liquid. Some adsistor, capacitance change, electrical conductivity, fiber optic chemical, and thermal conductivity sensors are sophisticated enough to distinguish between product and water.

Purpose of the Project

This report is based on testing performed only on discriminating sensors manufactured by Veeder-Root, as they are the most prevalent in California. We initiated a field study of discriminating sensors in response to local agency concerns that some of these sensors did not appear to operate properly when annual maintenance certification and inspections were conducted. Particular items of concern brought to our attention by local agency inspectors were:

- The inability of discriminating sensors to detect a layer of hydrocarbon-based product (i.e. gasoline) floating on top of water and to properly distinguish between water and product;
- The inability of polymer-based hydrocarbon detecting elements to alarm in a reasonable amount of time; and
- The inability of polymer-based hydrocarbon detecting elements to return to effective operation (recover) after exposure to hydrocarbons.

While this project was initially designed to address the aforementioned local agency concerns, we enlisted the help of discriminating sensor manufacturers and local agency inspectors to expand the scope of the study. The scope of the study included:

- Evaluating the functionality of discriminating sensors used in California (in response to the above listed concerns of local agency inspectors);
- Checking the adequacy of field-testing procedures for discriminating sensors (or work with manufacturers to develop field-testing procedures if they are not already available);
- Determining if discriminating sensors in the field perform consistently with the specifications outlined in their third-party evaluations; and
- Determining if the third-party evaluation protocol currently used is suitable for the sensor types tested using that protocol.

Coordination of the Field Testing

Since the focus of the testing was on the performance of sensors in the field, it was necessary to conduct testing at operating facilities where the sensors are installed. Three local agencies representing a cross section of California's UST population local regulatory governments volunteered to assist with this project. The City of Santa Ana, City of Santa Monica, and City of Oakland helped us to identify facilities within their jurisdictions that were using Veeder-Root discriminating sensors. In order to minimize the impact on owners, operators, and local agencies, we scheduled our field testing to coincide with the required annual inspections. The maintenance contractor performed the testing for the sensors while completing all the other scheduled annual certification work. Manufacturer's representatives were on hand to observe the testing, assist with the advanced setup and diagnostic features of the sensor control panel, and to answer technical questions.

Testing Procedure

In order to test the sensors during this evaluation, Veeder-Root prepared a draft testing procedure. We reviewed and provided comments on the draft test procedures, which were then

modified by Veeder-Root and re-submitted as a second draft. The second draft was the testing procedure used in our field evaluation. Modifications were made throughout the study, as deemed necessary by our staff on site. Modifications were included to minimize station downtime, and to test possible improvements to the protocol (such as the cleansing of sensors in white gas¹ to accelerate recovery of polymer strips.)

The basic test procedure was to immerse the discriminating sensor in fuel, water, or a fuel/water mixture to see if it alarmed appropriately (e.g., water and/or fuel). We modified the procedure by using a stopwatch to determine the length of time between sensor immersion and alarm, and the length of time for the sensor to recover after being removed from the liquid. We also noted the type and the depth of the liquid in which a sensor was immersed, as well as the type of alarm (fuel, water, or both water and fuel) the sensor registered.

Test procedures varied slightly between sensor models, due to differences in detection mechanisms. Veeder-Root's discriminating sensors can be classified in two general families based upon their fuel-sensing mechanisms: Ultrasonic sensors (model 794380-341), and Polymer Strip Sensors (all other models tested). Table I lists the Veeder-Root discriminating sensors tested in this study, including the mechanisms each sensor model uses to determine the presence of liquid and/or fuel, and the testing procedure used in our study.

TABLE I - Veeder-Root's Discriminating Sensors

Model Number	Application	VR Test Procedure	Water Sensing Mechanism	Fuel Sensing Mechanism
794380-320	Dispenser Pan	A	Ultrasonic	Polymer Strip
794380-350	Sump (Pump or Piping)	A	Ultrasonic	Polymer Strip
794380-322	Dispenser Pan	A	Float Switch	Polymer Strip
794380-352	Sump (Pump or Piping)	A	Float Switch	Polymer Strip
794380-360	Fiber Trench	A	Ultrasonic	Polymer Strip
794380-361	Fiber Trench	A	Ultrasonic	Polymer Strip
794380-362	Fiber Trench	A	Ultrasonic	Polymer Strip
794380-341	Interstitial	B	Ultrasonic	Capacitance Change

Data Collection

City of Santa Ana

SWRCB staff, local agency inspectors, maintenance contractors, and Veeder-Root representatives collected data for this project. Data collection began in Santa Ana in August 2000, where the local agency inspector, maintenance contractor, Veeder-Root representatives were present at each testing site. SWRCB staff was present at some of the Santa Ana sites. Veeder-Root representatives recorded the test data in Santa Ana. This data was forwarded to us for analysis. (See Table II for a summary of this data.)

¹ Since the time of testing we have heard from other manufacturers of polymer strip sensors that this practice, although common among service technicians, may have an adverse effect on the polymer strip sensor's continued functionality. SWRCB staff does not recommend cleansing sensors with white gas unless specifically instructed to do so by the sensor manufacturer.

SWRCB staff did not always witness testing in Santa Ana. Additionally, we were still refining the scope of data to be collected, testing procedures, and protocol for data collection. For these reasons, results of testing in Santa Ana were usually considered only when making general observations and conclusions in this report, not in making any specific calculations. An exception to this is test data for model 794380-341 sensors. Santa Ana test data for this model has been included in the calculations of this report, since the sample size in Santa Monica and Oakland was so small. The local agency inspector present at all Santa Ana sites furnished us with his reports on the sites equipped with model 794380-341 sensors, and this data was used in calculating pass/fail rates for that model.

City of Oakland and City of Santa Monica

Testing was conducted in Oakland and Santa Monica in October and November 2000. Local agency inspectors, Veeder-Root personnel, service technicians, and SWRCB staff were present at all facilities tested. SWRCB staff recorded all test data. Upon completion of testing, the data collected from Oakland and Santa Monica was compiled in a data table, which is summarized in Table III.

Table II - Summary of Veeder-Root Test Data from Santa Ana*

Dates of Testing	August 21 st -25 th , 2000
Number of Facilities Tested	8
Number of Sensors Tested	(model 794380-208) = 18 (model 794380-320) = 3 (model 794380-341) = 13 (model 794380-350) = 26 (model 794380-352) = 5 (model 794380-362) = 1 (model 794380-40x) = 10
Total Number of Sensors Tested	76

*Detailed test information not available for Santa Ana facilities

Table III - Summary of Test Data from Oakland and Santa Monica

Number of Facilities Tested	18
Number of Sensors Tested	(model 794380-320) = 2 (model 794380-322) = 1 (model 794380-341) = 6 (model 794380-350) = 8 (model 794380-352) = 49 (model 794380-360) = 1
Total Number of Sensors Tested	67
Pass/Fail Data for Model 794380-341	4 passes, 2 failures
Range of Response Times in Fuel and Fuel/Water Mix (794380-350)	3:26 to 42:50 (min:sec)
Range of Recovery Times in Fuel and Fuel/Water Mix (794380-350)	19:49 to 70:40 (min:sec)
Range of Response Times in Water (794380-352)	2 to 18 seconds
Average Response Time in Water (794380-352)	8 seconds
Range of Response Times in Fuel and Fuel/Water Mix (794380-352)	4:59 to 12:10 (min:sec)
Average Response Time in Fuel and Fuel/Water Mix (794380-352)	7 minutes, 15 seconds
Range of Recovery Times in Fuel and Fuel/Water Mix (794380-352)	0:27 to 52:29 (min:sec)
Average Recovery Time in Fuel and Fuel/Water Mix (794380-352)	17 minutes, 26 seconds

Discussion

Since the operating mechanism and testing procedure of the Veeder-Root model 794380-341 sensor are different than all the other sensors in our study, it is reasonable to divide the “discussion” section into two parts: one part for the 794380-341 (ultrasonic mechanism), and one for all of the other sensors in our study (polymer-strip mechanism).

Ultrasonic Mechanism (Veeder-Root Model 794380-341)

Our testing showed the 794380-341 interstitial fiberglass tank sensor performed unsatisfactorily. Eleven of 20 model 794380-341 sensors failed when tested in the field². Usually, the sensors detected the presence of liquid, but were unable to discriminate between fuel and water. Veeder-Root determined the failures are due to a faulty solder joint within the sensor, and is planning to make design changes to eliminate the problem. Since the sensor cannot reliably discriminate between fuel and water, Veeder-Root intends to reclassify the current 794380-341 sensor as non-discriminating³.

When testing the 794380-341 sensors in Santa Ana, we observed that they often came out of the tanks wet. The moisture was a clear, odorless and somewhat gooey film. When the film dried, it became milky white⁴. There appeared to be moisture in the interstitial spaces of the tanks these sensors are monitoring, but not enough to activate an alarm. Follow-up information from Santa Ana indicates that these sensors had to be cleaned before they would alarm properly when tested, and that this is a common occurrence observed by inspectors during routine sensor field certifications.

Polymer-Strip Mechanism (Veeder-Root Models 794380-320, 794380-322, 794380-350, 794380-352, 794380-360, 794380-361, and 794380-362)

The polymer-strip discriminating sensors consist of three separate sensing elements. The low and high liquid detectors are float switches or ultrasonic sensors depending on the model. The product-sensing element is a polymer strip that absorbs hydrocarbons. The strip is imbedded with small particles of conductive material (See Figure II). As the strip absorbs hydrocarbons, the material expands and the strip becomes less conductive (e.g. the resistance rises). When the resistance reaches a certain level (for Veeder-Root sensors this is set at approximately 250 kΩ to 500 kΩ) an alarm is activated.

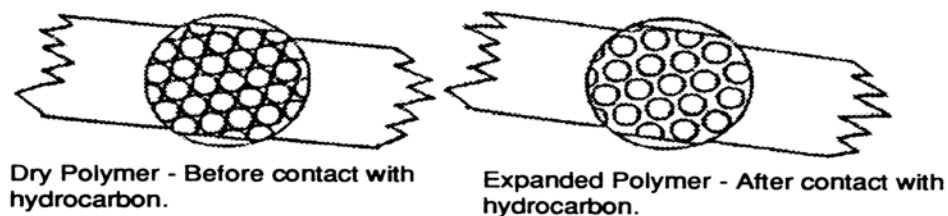


Figure II – Polymer strip used in discriminating sensors

² Includes data supplied by the local agency inspector present at Santa Ana test sites.

³ Veeder-Root has completed reclassification of the model 794380-341 sensor since this summary was originally prepared.

⁴ The local agency inspector present at these facilities was concerned that the liquid may include resin or adhesive used in construction of the fiberglass tanks where these sensors are installed.

The low and high-level liquid sensors proved to be generally effective. They typically activated a liquid alarm in less than the third-party specified time. On the few occasions that a sensor did not respond properly, the problem was usually diagnosed as faulty wiring or improper programming of the console and not a design problem.

While our field-testing showed the low and high level liquid sensors to be effective, several issues concerning the polymer strip were raised which may be cause for concern and further investigation. Other issues, such as control panel configuration and testing protocols, were also brought to light in the course of field-testing. The following paragraphs discuss these concerns in detail.

1. Response and recovery times of the polymer strip element when exposed to fuel were sometimes excessive, and not always consistent with third-party claims. Primary concerns include the length and variation of response and recovery times, as discussed below:

(a) Length of Response Times

The fuel alarm is activated only after enough fuel has permeated the polymer strip to raise its electrical resistance to a value of 250 k Ω -500 k Ω . The time required to reach the necessary electrical resistance varied from 5 to 12 minutes, with an average of just above 7 minutes. Typically the resistance in the strip did not change appreciably for several minutes. In the event of a catastrophic leak, this response time could lead to large amounts of fuel in the dispenser pan or containment sump. As the liquid level reaches the high-level liquid sensor a high level water alarm will sound, but it could still be many minutes before the polymer strip reacts to the fuel and activates a fuel alarm. This would be a major concern if the system is not configured for turbine shutdown when the high level water alarm is activated.

(b) Variation of Response Times

With the wide variation in response times between sensors of the same model tested in the same product, it is difficult to say exactly how long a polymer-strip sensor should typically take to alarm once exposed to fuel. This makes it difficult to establish field-testing guidelines, or to determine if a sensor is actually non-functional or just slow to respond.

(c) Length of Recovery Times

Recovery times often exceeded the third-party value of 17.17 minutes. Values ranged from under 1 minute to over 52 minutes, with an average of more than 17 minutes. Like a sponge in water, the strip swells when exposed to fuel. It must completely dry out and return to its original shape in order to come out of alarm. This can take quite awhile, depending on how saturated the strip is and how volatile the liquid is. In the interest of time, our test procedure called for a minimum amount of fuel, and for the sensor to be removed from fuel as soon as it alarmed. We even experimented with removing the sensor from fuel before it had alarmed in hopes of decreasing recovery times. Even so, the recovery times were high. Although the test protocol used in this study did not include long-term immersion of sensors in fuel, it is reasonable to believe that sensors immersed in fuel for extended periods of time (as would be the case in the event of an actual leak) would take even longer to recover, or may not recover at all.

2. Response and recovery times seem to vary with weather conditions.

(a) Warm and dry vs. cool and wet conditions

Although it is difficult to substantiate with hard data due to the inconsistency of our testing procedures⁵, the polymer strips tended to respond and recover more quickly in warmer weather. We observed that sensors tested in the sun and sensors tested during dry conditions recovered more quickly than sensors tested in rainy or colder weather. This may be due to the fact that in colder or more humid weather fuel is less volatile.

(b) Very cold conditions

The correlation between temperature and response/recovery time may become a major factor at extremely low temperatures. In our field evaluation, we did not test sensors in freezing conditions, so we do not know if the polymer strips are still effective at these temperatures. Is fuel volatile enough during freezing temperatures for the sensor to absorb the hydrocarbons and go into alarm? We posed this question to Veeder-Root in a letter. Nowhere in the third-party evaluation is temperature or humidity considered. We simply do not know how effective these sensors will be in extreme temperatures.

In addition to the polymer strips, we are also concerned about the functionality of float switches in freezing conditions, especially those monitoring shallow sumps and shallow under-dispenser containment boxes. It may be possible for condensation to freeze on a float switch and render it inoperable.

3. The frequency of data transmittal between the sensor and the control console is a factor in response and recovery times.

The console (e.g., TLS 350) “looks” at the status of each sensor or leak detection element in the UST system. It cycles through each sensor and element in the system before returning to the beginning. If multiple sensors and elements are built into the programming, it may take more time for the console to return to a particular sensor. As a result, facilities with a large number of sensors may take longer to activate an alarm at the console than those with a small number of sensors.

4. Alarm Settings and Pump Shutdown Features.

Many of Veeder-Root’s polymer-strip discriminating sensors have three different types of alarms: a low liquid alarm, a high liquid alarm, and a fuel alarm.

- The low liquid alarm is triggered by a float switch or ultrasonic mechanism located at or near the bottom of the sensor housing. This mechanism will “trip” whenever it is covered with fluid. It does not discriminate between water and fuel. This mechanism activates a warning (yellow light) at the control panel.
- The high liquid alarm is also triggered by a float switch or an ultrasonic mechanism, which is located a few inches from the top of the sensor housing.

⁵ In warm weather, the thin layer of fuel used on top of water evaporated completely before the sensor alarmed. The service person conducting the test had to add more fuel several minutes into the testing, causing very long response times. Therefore the correlation between temperature and response time which might otherwise have been evident is not readily recognized.

Again, this mechanism cannot discriminate between water and fuel. This mechanism activates an alarm (red light) at the control panel.

- A fuel alarm is triggered by a polymer strip that runs the length of the sensor housing, from the bottom of the sensor to the top float switch. Unless the polymer strip detects hydrocarbons, alarms from this mechanism are considered an indication of water intrusion. This mechanism activates an alarm (red light) at the control panel.

Both warnings and alarms are designed to alert the operator that there is something wrong with the UST system. Each requires investigation, and should receive an appropriate response from the operator. Warnings and alarms may also be programmed to activate pump shut-down, which turns off the turbine so that the UST cannot operate. Pump shut-down is generally only done with alarms.

If warnings or alarms are ignored and the liquid level exceeds the height of the top float switch, the sensor no longer detects additional fuel or water entering the sump. The sensor becomes ineffective and no longer provides leak detection; therefore, pump shut down at the high level alarm is a must.

5. High Vapor Mode

Another feature of the Veeder-Root control panel is the “High Vapor Mode.” This operating mode is designed for use in areas where background levels of hydrocarbon vapors are high enough to activate the fuel alarm, even though the UST system is not leaking. This may be due to a previous release of product, or possibly the materials and adhesives used in the construction of the UST itself may release vapors. “High Vapor Mode” is a tool used to eliminate false alarms. When the console is configured in “High Vapor Mode,” the sensor will not sound a fuel alarm unless it detects both the presence of liquid and hydrocarbons. The low liquid alarm mechanism must be triggered and the resistance in the polymer strip must be high enough to trigger a fuel alarm.

Although the sensors we tested in “High Vapor Mode” seemed to be generally effective, they have not been third-party certified for operation in “High Vapor Mode” versus “Low Vapor Mode.”

6. Lack of Field Testing Procedures.

Although each manufacturer may provide its own manual of procedures for testing discriminating sensors, there are several different tests a technician can run. Some agencies require a test of the low and high liquid alarms only. Some agencies require testing the sensors in fuel and water separately. And some agencies require each sensor to be tested in fuel, in water, and in a fuel/water mixture.

Based on the results of our field testing, we determined that it is necessary to periodically test all sensors in fuel. Even though the consoles are designed to run diagnostics on the sensors, the consoles do not always recognize problems with sensors or their wiring. We encountered two or three sensors that were either not programmed properly or had wiring problems. These programming or wiring problems were only discovered through

physical testing of the sensors in fuel. We might also benefit from testing sensors in a water/product mixture, since it simulates more accurately conditions encountered in parts of the UST system that are prone to water intrusion.

7. Degradation of Polymer Strips

Our testing provided no conclusive information as to the long-term reliability of polymer-strip sensors in harsh environments, or after repeated/prolonged exposure to hydrocarbons. Results of testing showed a wide variation in the response and recovery times for the polymer strip sensors. In many cases these times exceeded the third-party specifications.

The manufacturers of polymer strips claim the strips are testable and reusable, but each time the strip comes in contact with fuel, it apparently either retains some of the volatile compounds within its material or its elasticity is compromised after repeated/prolonged hydrocarbon exposure. Once exposed to fuel, the sensor is no longer “good as new.” Eventually, the sensor will degrade so much that either it may not recover from an alarm condition (the resistance will not drop to the point that it comes out of alarm), or the probability of false alarms will be very high. We do not know how many testing cycles a sensor can reasonably accommodate.

8. Volatility of Stored Product

The polymer strip is most readily activated by volatile hydrocarbons, with unleaded fuel and white gas producing the most rapid responses. The sensors also recovered from exposure to these fuels fairly consistently. Diesel fuel would activate an alarm, but not nearly as quickly as the more volatile unleaded fuel. Recovery times were very slow. Veeder-Root suggested cleaning sensors exposed to diesel fuel with white gas in order to speed up recovery. Technicians told us that sensors exposed to diesel must often be air-dried for days, and even then, sometimes never recover.

Although we encountered some waste oil UST systems being monitored by Veeder-Root discriminating sensors, we did not test the sensors in waste oil. Veeder-Root’s sensors are not third-party evaluated for use in waste oil applications. We are concerned that waste oil may not be volatile enough to trigger an alarm from polymer strip sensors.

9. Third-Party Protocol is Inappropriate for Polymer Strip Sensors

Third-party testers have been using standard liquid point detection protocols to evaluate the polymer-strip sensors. These protocols are usually designed for mechanical or electrical switching devices that do not use chemical reactions like the polymer strips. It may be necessary to develop a protocol that takes into account the unique aspects of polymer-strip sensors. Ability to alarm and recover in a variety of environmental conditions should be assessed. The impact of repeated exposure of these sensors to fuel on response time and recovery time should also be evaluated.

APPENDIX II
Workplan for Phase II of the Field Evaluation

SWRCB Sensor Field Evaluation Workplan (Phase II) – July 3, 2001

Team Members

Project Supervisor: Shahla Farahnak, P.E.
Project Coordinator: Scott Bacon
Assistant Coordinator: Raed Mahdi
Field Testing Staff: Raul Barba, Eric Luong, and Jennifer Redmond

Purpose of the Project

This project is intended to evaluate the functionality of liquid and vapor sensors used to monitor UST systems. The focus will be on “real world” effectiveness, with testing performed at operating facilities where the sensors are currently installed. The study is designed to:

- Evaluate the functionality of sensors used in California;
- Check the adequacy of field-testing procedures for sensors (or work with manufacturers to develop field-testing procedures if they are not already available);
- Determine if sensors in the field perform consistently with the specifications outlined in their third-party evaluations; and
- Determine if the third-party evaluation protocol currently used is suitable for each of the sensor types evaluated with that protocol.

Coordinating Field Efforts

In order for us to test at a UST facility, several people must be present or notified. At a minimum, this will include SWRCB staff and a service technician on site, as well as notification of the facility owner/operator. Additionally, local agency inspectors and sensor manufacturers may be present. We plan to work with local agencies and maintenance contractors to coincide our testing with the required annual maintenance inspections already scheduled at the facilities

Data Collection Process

- ***Field Testing Method*** – Experienced service technicians will conduct the testing. They will access sensors in sumps, tank interstice, dispenser pans, excavation linings, and monitoring wells. The sensors will be immersed in water at a depth corresponding to their third-party evaluation. In addition, discriminating sensors will be tested in fuel and/or a fuel/water mixture.
- ***Data Recording*** – Our staff will observe the testing and record data. We will record sensor response and recovery time, as well as information about the sensor make, model, and application. Additionally, we will record data about the facility and the condition of the area the sensor is located in. Through careful collection and analysis of data, we hope to determine what factors may adversely effect sensor performance.
- ***Industry Professional’s Survey*** - In addition to the data collected from field-testing, we will survey experienced maintenance technicians and inspectors. Their responses will be used to supplement our field data and give us a clearer picture of sensor effectiveness.

Safety Considerations

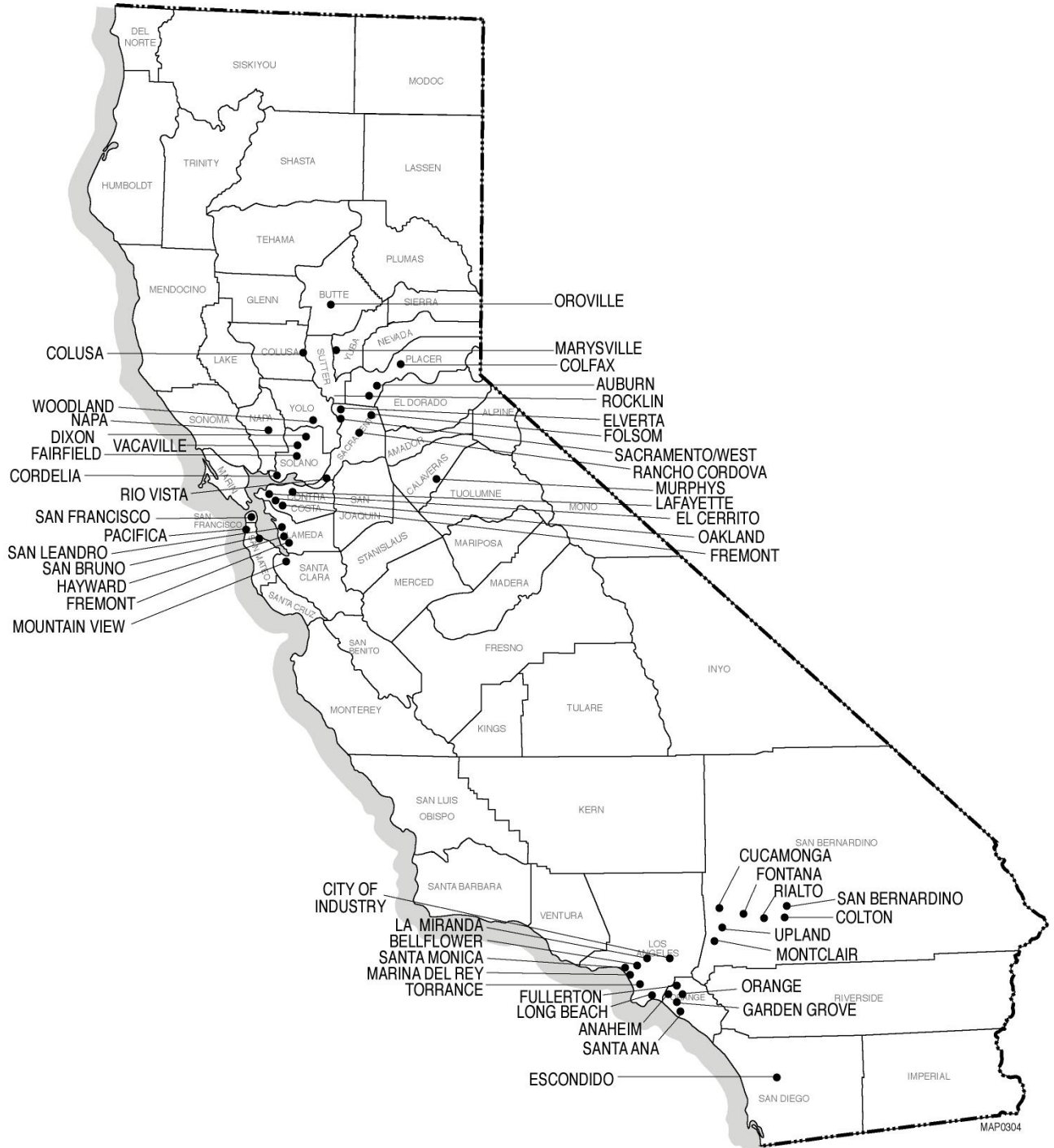
Qualified contractors will perform all hands-on testing. They have been trained to safely deal with the equipment and hazardous substances found at the facilities where our testing will take place. Our staff will only observe and record data, but all applicable standards of safety will be adhered to. This includes, but is not limited to, proper securing of the work area from traffic hazards.

Final Report/Summary

A thorough report will be completed at the end of field-testing. It will detail our testing activities and present the data collected from both the tests and completed surveys. In addition, the report will state conclusions and recommendations based on the results of our study.

APPENDIX III
Location of Facilities Included in the Field Evaluation

Location of Facilities Included in the Field Evaluation of Underground Storage Tank System Leak Detection Sensors



APPENDIX IV

Field Data Collection Forms

SWRCB SENSOR FIELD EVALUATION SITE DATA COLLECTION FORM

Site # _____

SITE INFORMATION

Date:	Time Testing Begins:	Time Testing Ends:
Facility Name:		Address:
Facility Ownership: Major Oil <input type="checkbox"/> Independent Oil <input type="checkbox"/> Government Agency <input type="checkbox"/> Other:		
Tank Type: Single-Wall <input type="checkbox"/> Double-Wall <input type="checkbox"/> Steel <input type="checkbox"/> Fiberglass <input type="checkbox"/> Dry <input type="checkbox"/> Hydrostatic <input type="checkbox"/>		
Piping Type: Single-Wall <input type="checkbox"/> Double-Wall <input type="checkbox"/> Pressurized <input type="checkbox"/> Suction <input type="checkbox"/> Steel <input type="checkbox"/> Fiberglass <input type="checkbox"/> Flex <input type="checkbox"/> Fiber Trench <input type="checkbox"/>		
# of Tanks:	# of Sumps:	# of Dispensers:

STAFF

SWRCB Staff Present:	
Local Agency Staff Present	Agency:
Service Technician(s) Conducting Test:	
Contractor:	Years in Industry:
Manufacturer's Representatives:	Manufacturer:

WEATHER CONDITIONS

Temperature at Start of Testing:	Temperature at End of Testing:
Humidity at Start of Testing:	Humidity at End of Testing:
General Conditions: Sunny <input type="checkbox"/> Cloudy <input type="checkbox"/> Windy <input type="checkbox"/> Light Rain <input type="checkbox"/> Heavy Rain <input type="checkbox"/> Fog <input type="checkbox"/> Other:	

COMMENTS:

SWRCB SENSOR FIELD EVALUATION, SENSOR DATA COLLECTION FORM

EQUIPMENT INFORMATION

Sensor Make:		Sensor Model:	
Sensor Serial #:		Sensor Manufacture Date:	
Control Panel Make:		Control Panel Model:	
Control Panel Serial #:		Control Panel Manufacture Date:	
Operating Principle: Float Switch <input type="checkbox"/> Ultrasonic <input type="checkbox"/> Product Permeable <input type="checkbox"/> Optical <input type="checkbox"/> Capacitance Change <input type="checkbox"/> Product Soluble <input type="checkbox"/> Thermal Conductivity <input type="checkbox"/> Conductivity <input type="checkbox"/>			
Discriminating? Y N	Continuous? Y N	Reusable? Y N	Listed in LG-113? Y N

APPLICATION INFORMATION

Sensor Location: Tank Interstice <input type="checkbox"/> Pump Sump <input type="checkbox"/> Fill Sump <input type="checkbox"/> UDC <input type="checkbox"/> Vapor Well <input type="checkbox"/> Groundwater Well <input type="checkbox"/> Trench Liner <input type="checkbox"/>	
Is Sensor at Lowest Point? Yes No NA	Is Wiring Connected Properly? Yes No NA
Total # of Sensors Recorded on this Form:	
Sensor Location... (check all that apply)	Is Clean and Dry <input type="checkbox"/> Contains Water <input type="checkbox"/> Contains Debris <input type="checkbox"/> Brine-Filled <input type="checkbox"/> Contains Product <input type="checkbox"/> Contains Backfill <input type="checkbox"/> Has Strong Vapor Smell <input type="checkbox"/>
Sensor is Monitoring for the Presence of...	Regular Unleaded <input type="checkbox"/> Mid-Grade Unleaded <input type="checkbox"/> Premium Unleaded <input type="checkbox"/> Water <input type="checkbox"/> Diesel <input type="checkbox"/> Brine <input type="checkbox"/> Waste Oil <input type="checkbox"/> Other:
Tank/Sump/UDC Monitored by Sensor is...	Steel <input type="checkbox"/> PVC/Plastic <input type="checkbox"/> Fiberglass <input type="checkbox"/> Membrane/Liner <input type="checkbox"/> HDPE <input type="checkbox"/> Other:
Tank/Sump/UDC Manufacturer:	

WATER TEST (Low)

Water Height:	Response Time
Recovery Time	Pump Shut-Down Yes No NA
Alarm Activated: Water Product Both None	Test Result: Pass Fail

WATER TEST (High)

Water Height:	Response Time
Recovery Time	Pump Shut-Down Yes No NA
Alarm Activated: Water Product Both None	Test Result: Pass Fail

PRODUCT TEST

Product Height:	Product Used:
Response Time	
Recovery Time	Pump Shut-Down Yes No NA
Alarm Activated: Water Product Both None	Test Result: Pass Fail

PRODUCT ON WATER TEST

Water Height:	Product Thickness:
Response Time:	Recovery Time:
Alarm Activated: Water Product Both None	Pump Shut-Down Yes No NA
Product Used:	Test Result: Pass Fail

After testing this sensor was: Repaired¹ ☐ Replaced ☐ Re-Tested² ☐ Re-Installed ☐

COMMENTS:

¹ Describe repairs in Comments section

² If the sensor is re-tested, record test data in another sensor form and attach it to the back of this form

Veeder-Root Discriminating Sensor Field Performance Test

Site Address: _____ Date: _____

Testing Contractor: _____ SWRCB Staff: _____

Weather Conditions: _____ Diameter of test apparatus (in.): _____ Site ID #: _____

	Sensor Model	High Water Level				Fuel					Water/Fuel Mixture						Pass Or Fail?
		Water Level (in.)	Response		Recovery Time (mm:ss)	Fuel Level (in)	Time in Fuel (mm:ss)	Response		Recovery Time (mm:ss)	Water Level (in.)	Fuel Thickness (in.)	Time in Liquid (mm:ss)	Response		Recovery Time (mm:ss)	
			Time to Alarm (mm:ss)	Alarm Type (WFN)				Time to Alarm (mm:ss)	Alarm Type (WFN)					Time to Alarm (mm:ss)	Alarm Type (WFN)		
S1																	
S2																	
S3																	
S4																	
T1																	
T2																	
T3																	
T4																	

Comments:

- 1) Sensor Location: T1 to T4 are sensors in tanks 1-4, S1 to S4 are sensors in the turbine sumps of tanks 1-4, additional sensor locations should be included in the "comments" section of this form.
- 2) Alarm Type: W = Water, F = Fuel, N = None. Include both W and F if applicable.
- 3) Times: All times will be taken from the moment the sensor is placed in the fluid. The clock will not be zeroed between alarm activation and recovery.
- 4) Indicate any sensors that were replaced, noting the model # of the old and new sensors as well as the reason for replacement.

APPENDIX V

Sensor Survey Distribution Letter, Survey Form, Results, and Comments



Winston H. Hickox
Secretary for
Environmental
Protection

State Water Resources Control Board

Division of Clean Water Programs

1001 I Street • Sacramento, California 95814 • (916) 341-5871
Mailing Address: P.O. Box 944212 • Sacramento, California • 94244-2120
FAX (916) 341-5808 • Internet Address: <http://www.swrcb.ca.gov>



Gray Davis
Governor

October 24, 2001

TO: Interested Parties

SURVEY FORM FOR SENSOR FIELD STUDY

We are sending this letter to you, as someone who may have expertise in the performance of the various sensors used in UST systems. We are concerned about the performance of these sensors, specifically those in tank-top sumps, tank annular spaces, and under dispenser containment. As you know, their performance is critical in detecting leaks. Therefore, we have initiated our own study to evaluate their effectiveness under actual operating conditions.

We plan to visit 200 operating UST facilities and collect data on sensor performance. However, we recognize that our field study is limited and would be incomplete without input from those who have valuable first-hand experience with these sensors. Therefore, we are requesting your assistance to complete the enclosed survey form and return it to us. This will allow us to incorporate your knowledge and experience into our study. We estimate it will take approximately 30 minutes to complete the entire survey, however we are interested in your views even if you can only complete a portion.

Please distribute the survey to anyone in your organization who routinely works with UST leak detection sensors. This includes, but is not limited to, service technicians, inspectors, installers, and environmental managers. Please return the completed surveys by **November 15, 2001** to:

Attention: Scott Bacon
State Water Resources Control Board
Department of Clean Water Program
P.O. Box 944212
Sacramento, CA 94244-2120
Fax: (916) 341-5808

If you prefer, you may complete and submit the survey online at:
<http://www.calcupa.net/support/index.htm>

If you have any questions regarding this survey, please contact Scott Bacon at (916) 341-5873 or email: bacons@cwps.wrcb.ca.gov.

Sincerely,

- ORIGINAL SIGNED BY -

Shahla Dargahi Farahnak, P.E., Chief
Engineering Unit 2
Underground Storage Tank Program

Enclosure

California Environmental Protection Agency



Recycled Paper

UST SENSOR STUDY SURVEY

STATE WATER RESOURCES CONTROL BOARD

(Please answer all the questions that are applicable based on your experience in the field)

Information provided by: – (Leave blank if you prefer to submit this survey anonymously)

Name: _____ **Company/Agency:** _____
Address: _____ **Telephone:** _____

GENERAL INFORMATION

1. What is your affiliation? ☐ Local Agency Inspector ☐ Technician ☐ Consultant
☐ Owner/Operator ☐ Other (*Specify*) _____
2. How many years of experience do you have in the UST field? _____
3. Average number of UST facilities you inspect/service monthly? _____ ☐ Not applicable

OVERALL SENSOR INFORMATION

4. Do you perform/require a functional test (i.e. accessing the sensors and activating an alarm by flipping them over, immersing them in liquid, etc.) of all sensors during the annual UST monitoring equipment certification? ☐ Yes ☐ No
5. What percentage of the sensors you encounter in the field are failing the functional tests?
☐ <5% ☐ 5-10% ☐ 10-20% ☐ 20-30% ☐ 30-40% ☐ 40-50% ☐ >50%
6. What percentage of the sensor failures are due to the following factors:
- | | | | | | | | |
|------------------|------------------------------|--------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|-------------------------------|
| a) Poor design: | <input type="checkbox"/> <5% | <input type="checkbox"/> 5-10% | <input type="checkbox"/> 10-20% | <input type="checkbox"/> 20-30% | <input type="checkbox"/> 30-40% | <input type="checkbox"/> 40-50% | <input type="checkbox"/> >50% |
| b) Installation: | <input type="checkbox"/> <5% | <input type="checkbox"/> 5-10% | <input type="checkbox"/> 10-20% | <input type="checkbox"/> 20-30% | <input type="checkbox"/> 30-40% | <input type="checkbox"/> 40-50% | <input type="checkbox"/> >50% |
| c) Maintenance: | <input type="checkbox"/> <5% | <input type="checkbox"/> 5-10% | <input type="checkbox"/> 10-20% | <input type="checkbox"/> 20-30% | <input type="checkbox"/> 30-40% | <input type="checkbox"/> 40-50% | <input type="checkbox"/> >50% |
| d) Programming: | <input type="checkbox"/> <5% | <input type="checkbox"/> 5-10% | <input type="checkbox"/> 10-20% | <input type="checkbox"/> 20-30% | <input type="checkbox"/> 30-40% | <input type="checkbox"/> 40-50% | <input type="checkbox"/> >50% |
| e) Tampering: | <input type="checkbox"/> <5% | <input type="checkbox"/> 5-10% | <input type="checkbox"/> 10-20% | <input type="checkbox"/> 20-30% | <input type="checkbox"/> 30-40% | <input type="checkbox"/> 40-50% | <input type="checkbox"/> >50% |
| f) Other: | <input type="checkbox"/> <5% | <input type="checkbox"/> 5-10% | <input type="checkbox"/> 10-20% | <input type="checkbox"/> 20-30% | <input type="checkbox"/> 30-40% | <input type="checkbox"/> 40-50% | <input type="checkbox"/> >50% |
7. Sensor failure is most common in: ☐ Steel Tanks ☐ Dry Interstice Fiberglass Tank
☐ Wet Interstice Fiberglass Tank ☐ Tank-Top (pump/fill) Sumps
☐ Under Dispenser Containment ☐ Location is not a factor in sensor failure

SENSOR COMPARISON

8. Please complete this section to the best of your knowledge:

	Float switch	Polymer strip	Optical Prism	Ultrasonic	Conductivity	Capacitance change
% failure rate						
* Indicate most common reason(s) for failure						

*Failure Reasons: P = Programming M = Maintenance I = Installation T = Tampering
PD = Poor Design Other = Please indicate

9. What specific make(s) and/or model(s) of sensor are **most** reliable? _____

10. What specific make(s) and/or model(s) of sensor are **least** reliable? _____

DISCRIMINATING SENSORS

11. What percentage of the sensors you use/inspect/service are discriminating sensors?

- Tank Interstice: ☐ <5% ☐ 5-10% ☐ 10-20% ☐ 20-30% ☐ 30-40% ☐ 40-50% ☐ >50%
- Turbine Sumps: ☐ <5% ☐ 5-10% ☐ 10-20% ☐ 20-30% ☐ 30-40% ☐ 40-50% ☐ >50%
- Under Dispenser: ☐ <5% ☐ 5-10% ☐ 10-20% ☐ 20-30% ☐ 30-40% ☐ 40-50% ☐ >50%

12. Based on your experience, discriminating sensors are _____ when compared to non-discriminating sensors?

- ☐ **More** reliable ☐ **Less** reliable ☐ **Equally** reliable

13. For discriminating sensors using polymer strip, what is the typical time for each of the following?

a) response in unleaded fuel:

- ☐ <30sec ☐ 30-60sec ☐ 1-3min ☐ 3-5min ☐ 5-10min ☐ 10-20min ☐ >20min

b) recovery in unleaded fuel:

- ☐ <1min ☐ 1-3min ☐ 3-5min ☐ 5-10min ☐ 10-20min ☐ >20min ☐ Not reusable

c) response in diesel fuel:

- ☐ <30sec ☐ 30-60sec ☐ 1-3min ☐ 3-5min ☐ 5-10min ☐ 10-20min ☐ >20min

d) recovery in diesel fuel:

- ☐ <1min ☐ 1-5min ☐ 5-15min ☐ 15-30min ☐ 30-60min ☐ >60min ☐ Not reusable

14. Is there a change in response times for polymer strip sensors after repeated exposure to fuel?
- ☐ Response time for polymer-strip sensors **increases** after repeated exposure to hydrocarbons.
 - ☐ Response time for polymer-strip sensors **decreases** after repeated exposure to hydrocarbons.
 - ☐ Response time for polymer strip sensors **does not change** after repeated exposure to hydrocarbons.

15. Which of the following methods do you most often use/require when testing discriminating sensors?
- ☐ Test in **water** only
 - ☐ Test in **product** only
 - ☐ Test in **both** product and water
 - ☐ Flip sensor over
 - ☐ I do not test/require testing of discriminating sensors

PUMP SHUT-DOWN FEATURE

16. What is the typical time delay between sensor activation and pump shut-down?
- ☐ <5sec ☐ 5-10sec ☐ 10-30sec ☐ 30-45sec ☐ 45-60sec ☐ 1-2min ☐ >2min
17. For sensors programmed for pump shut-down, what percent of them shut down the pump?
- ☐ <5% ☐ 5-10% ☐ 10-20% ☐ 20-30% ☐ 30-40% ☐ 40-50% ☐ >50
18. What are the most common reason(s) for failure of the pump shut-down?
- ☐ Programming
 - ☐ Maintenance
 - ☐ Installation
 - ☐ Tampering
 - ☐ Relay box (Equipment problems)
 - ☐ Other (Specify) _____

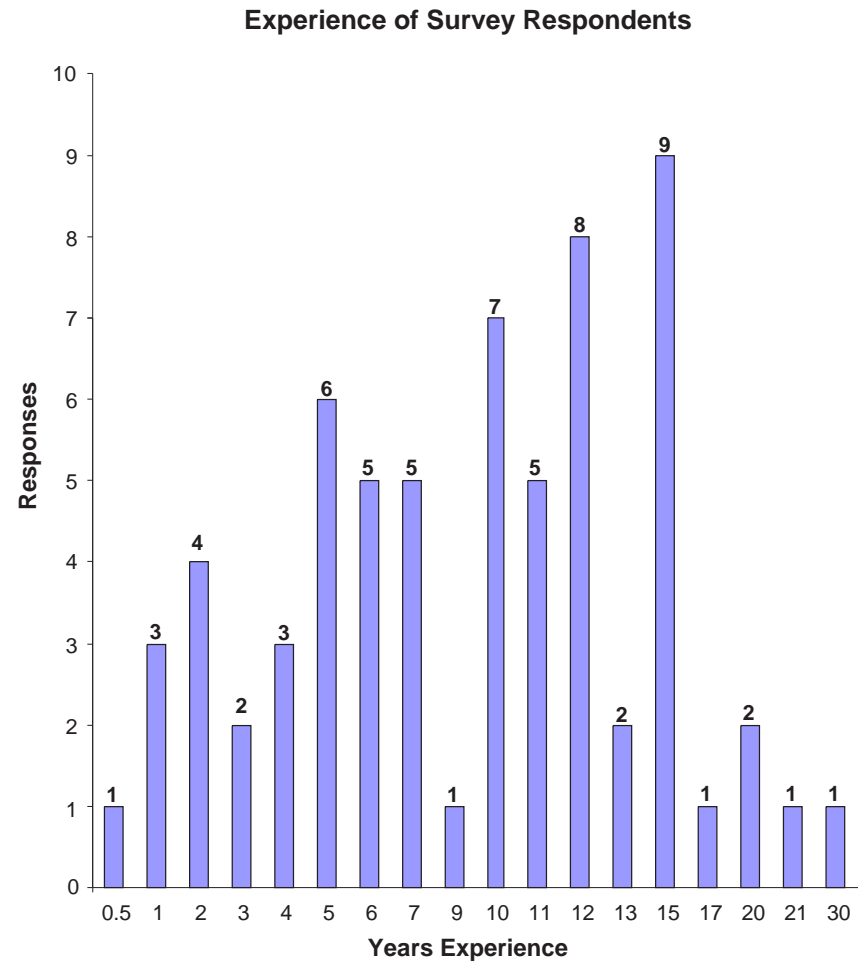
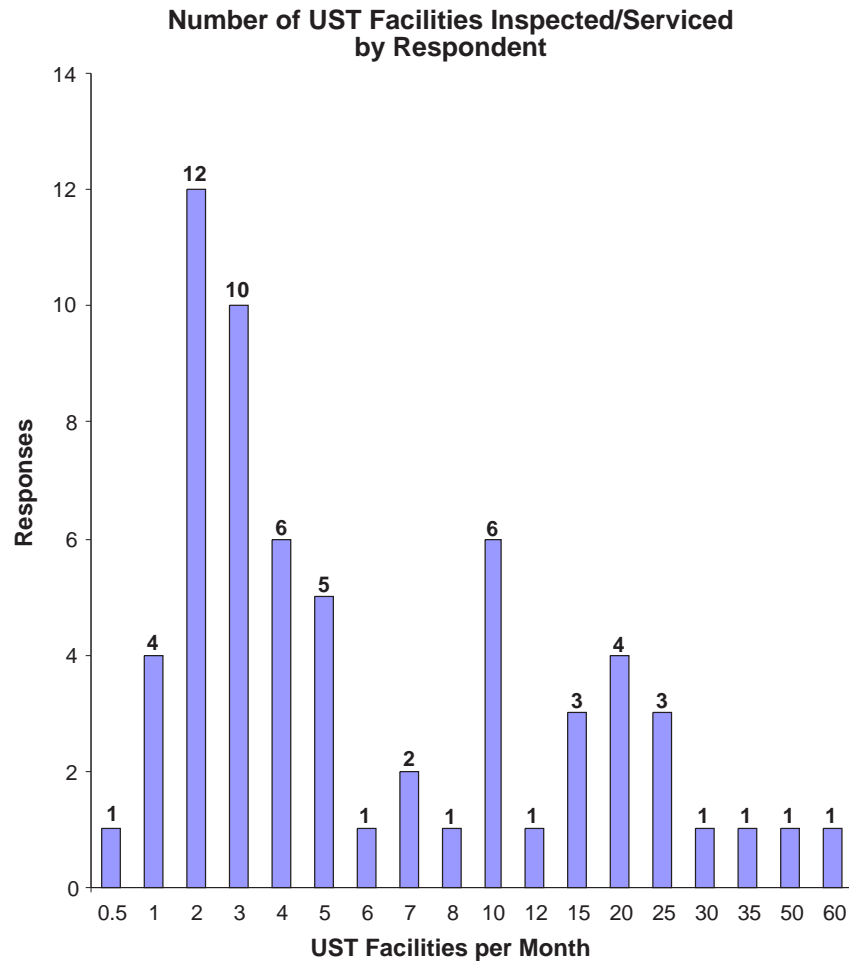
ADDITIONAL INFORMATION

19. What changes can be made to improve sensor reliability? _____
- _____
- _____
- _____
20. Do you have any other comments you would like to share with us? _____
- _____
- _____
- _____
- _____

SWRCB Sensor Field Evaluation, Survey Results

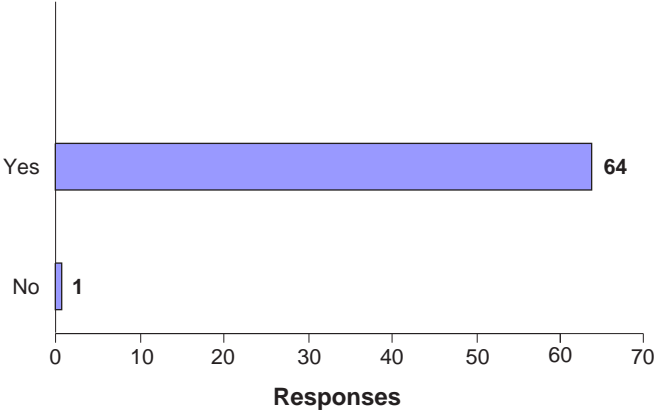
71 local agency inspectors and service technicians responded to the survey. The following tables summarize their responses to a variety of questions on UST leak detection sensors.

ABOUT THE RESPONDENTS

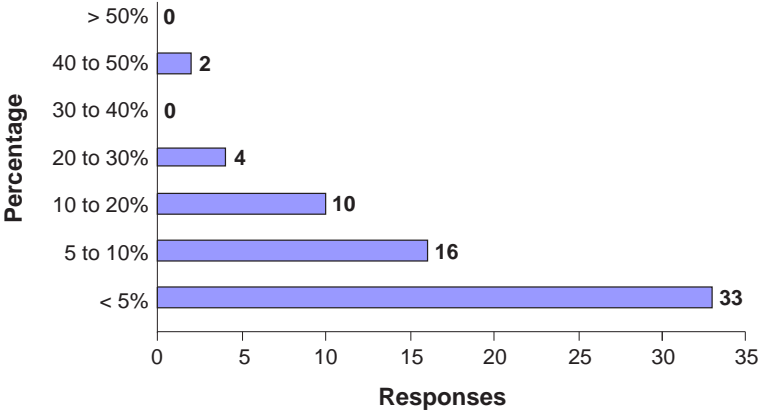


GENERAL SENSOR INFORMATION

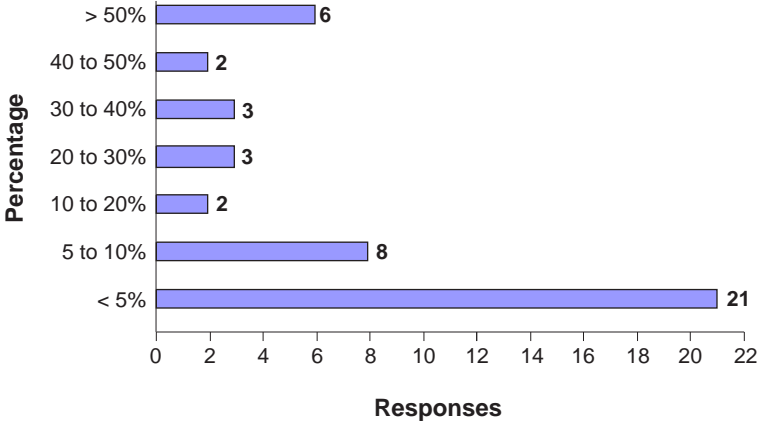
Do you Require Functional Test of Sensors?



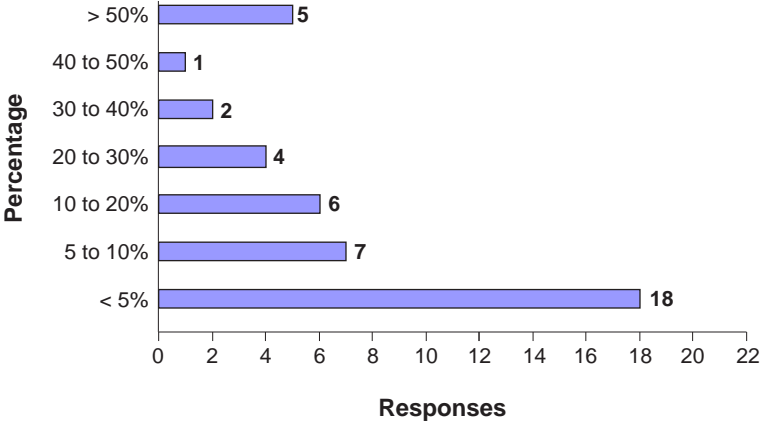
Percentage of Sensors Failing Functional Test



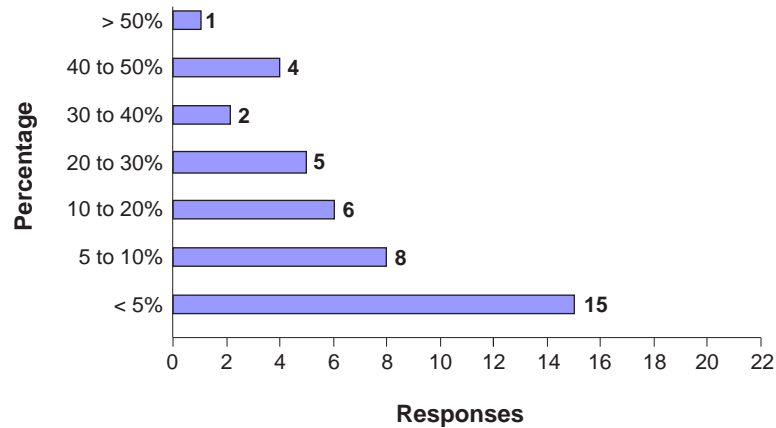
What Percentage of Sensor Failures are Due to Poor Design?



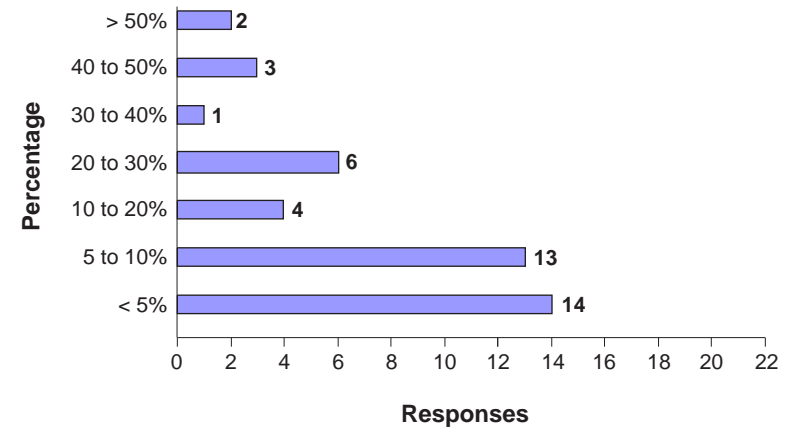
What Percentage of Sensor Failures are Due to Poor Installation?



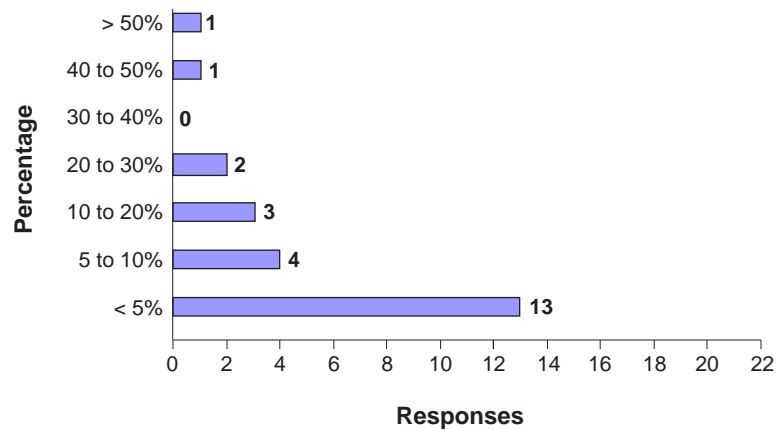
What Percentage of Sensor Failures are Due to Poor Maintenance?



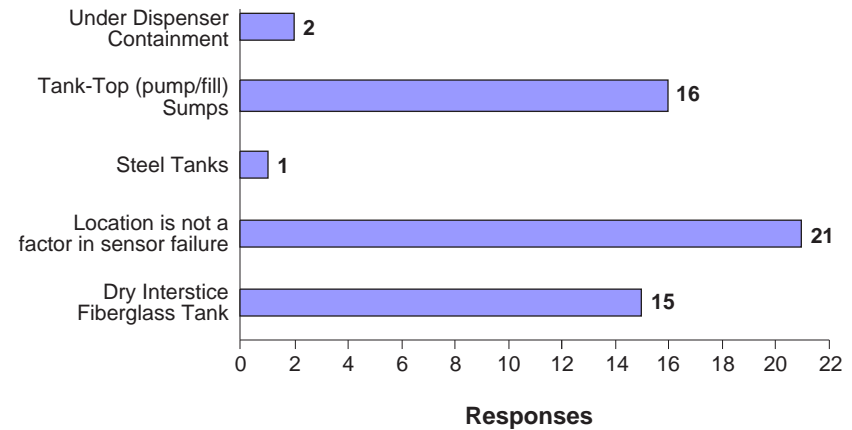
What Percentage of Sensor Failures are Due to Improper Programming?



What Percentage of Sensor Failures are Due to Tampering?

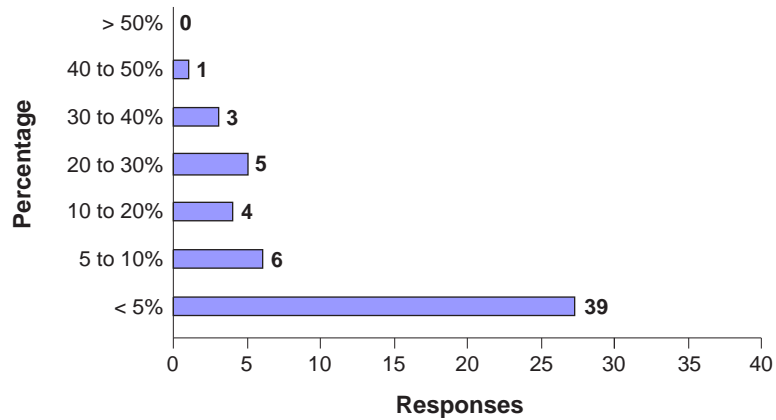


Location Where Sensor Failure is Most Common

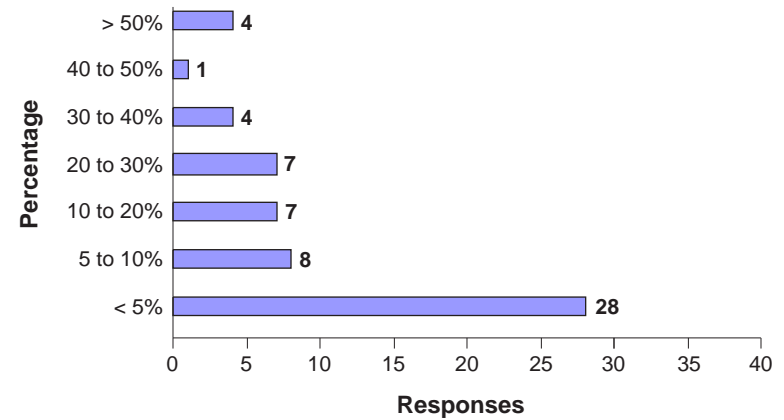


DISCRIMINATING SENSOR INFORMATION

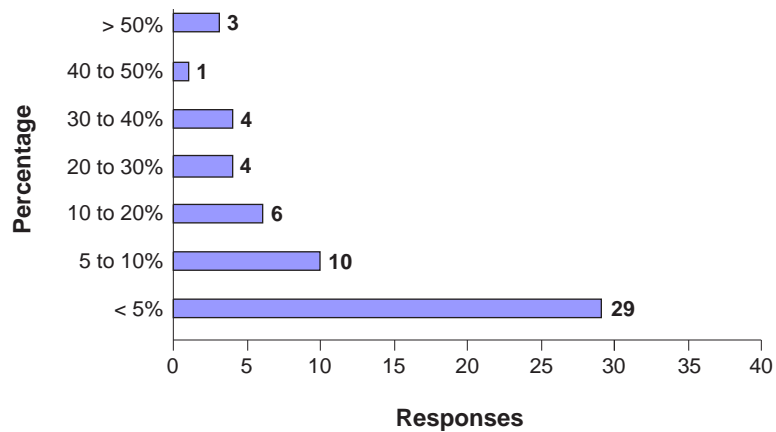
Percentage of Discriminating Sensors in Tank Interstice



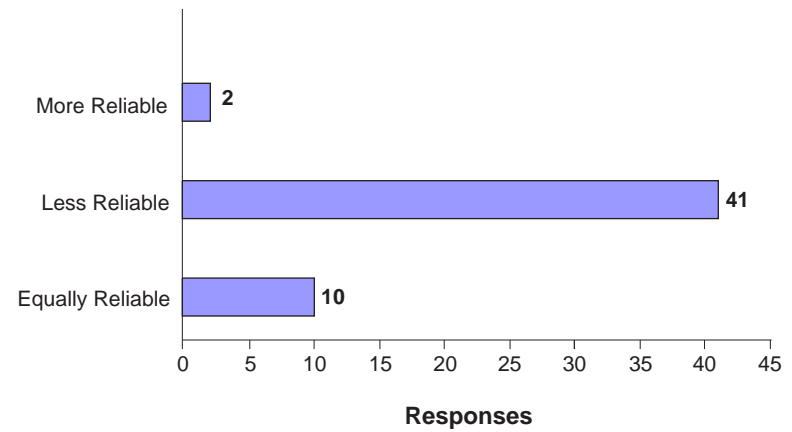
Percentage of Discriminating Sensors in Turbine Sumps



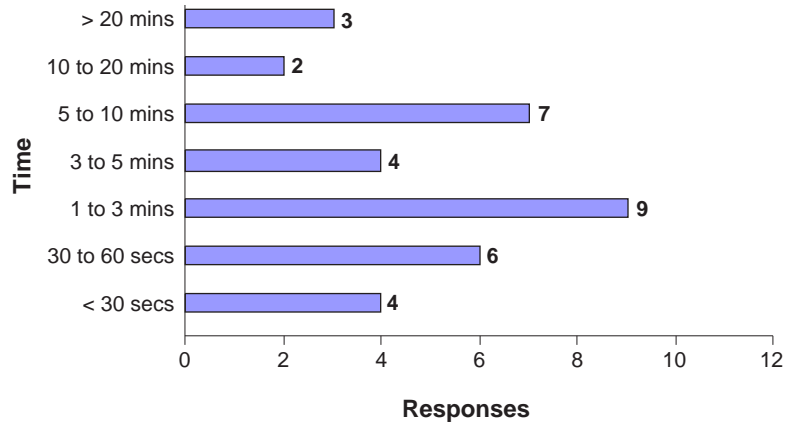
Percentage of Discriminating Sensors in UDC



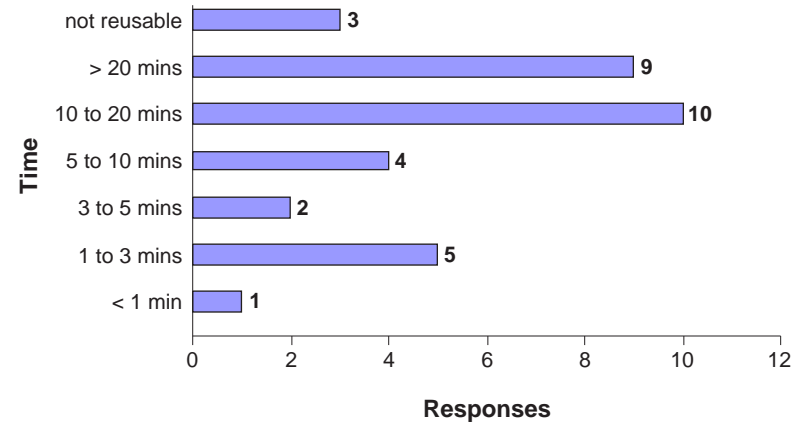
Reliability of Discriminating Sensors as Compared to Non-Discriminating



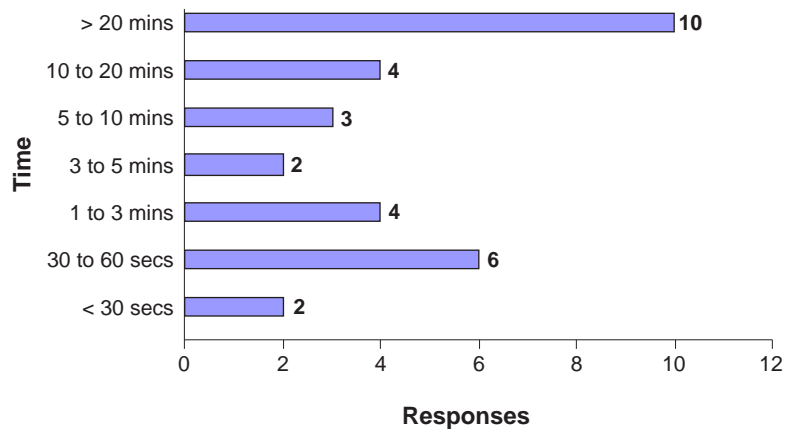
Discriminating Sensor Response Time in Unleaded Fuel



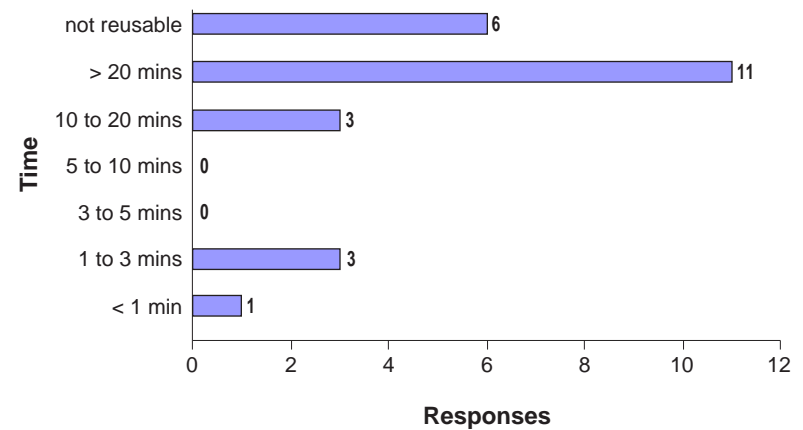
Discriminating Sensor Recovery Time in Unleaded Fuel



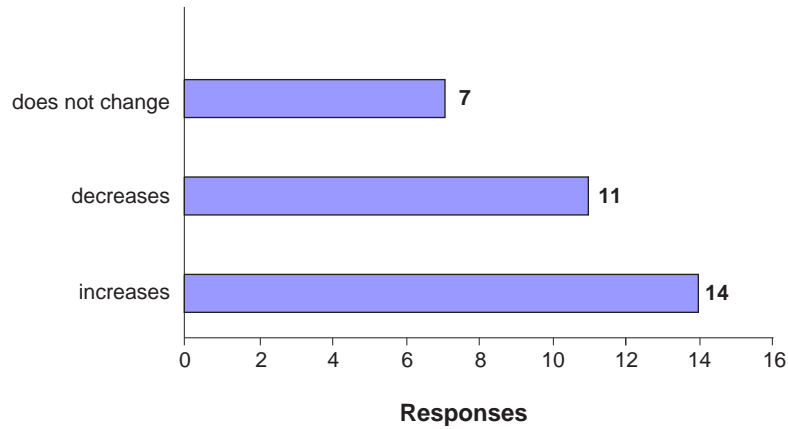
Discriminating Sensor Response Time in Diesel Fuel



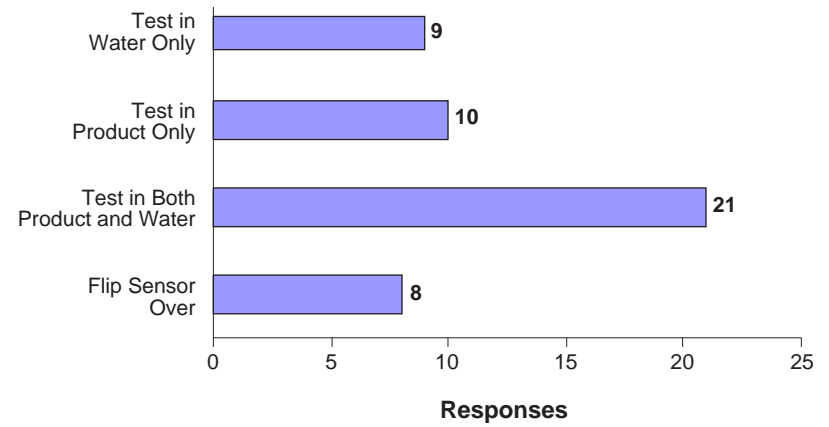
Discriminating Sensor Recovery Time in Diesel Fuel



Changes in Response Time for Polymer Strips After Repeated Exposure to Fuel

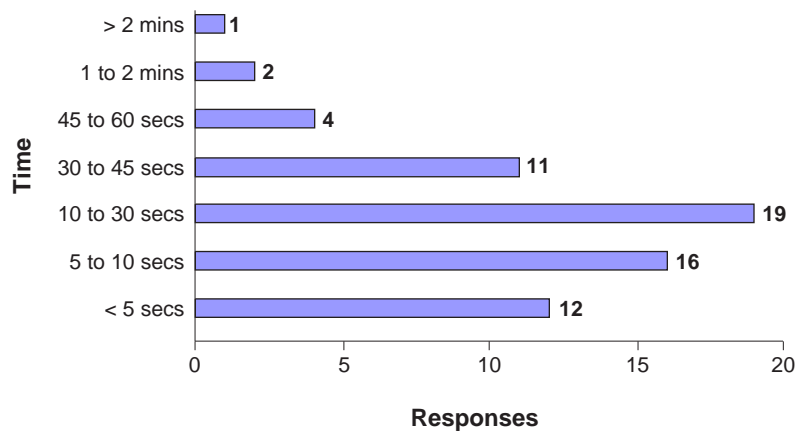


How are Discriminating Sensor Being Tested?

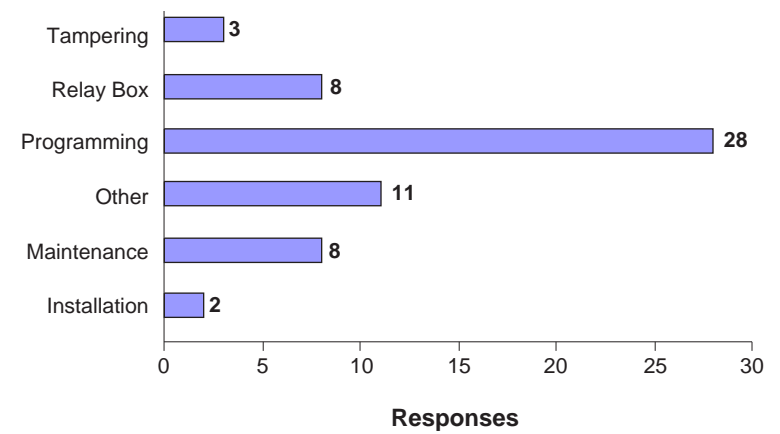


PUMP SHUT-DOWN INFORMATION

Pump Shut-Down Delay Time



Reason for Failure of Pump Shutdown



Online Survey Comments and Recommendations for the Sensor Field Evaluation of Underground Storage Tanks:

This is a compilation of comments and recommendations we received from our survey participants. These comments represent the views of the participants surveyed and may not reflect the opinions of the SWRCB.

- Discriminating sensors must be able to be tested in the actual product and must clear within a few minutes.
- Improve maintenance of sensors and replace outdated ones.
- The polymer strip type sensor appears to be a poor design for immediate identification of a leak. Remove this type from the approval list.
- Do not allow the use of sensors associated with the MSA Tankguard. I'm not sure, but I believe that they are polymer strip discriminating sensors. They have an extremely low response and recovery time of about 15-20 minutes. Also the sensitivity of the MSA Tankguard can be adjusted and always seems to need to be adjusted at each inspection. The alarm may not sound when the sensor is being tested in liquid, but then sound when it is not being tested. I do not trust the reliability of these sensors.
- Operator training, proper maintenance and tamper proofing.
- Eliminate discriminating sensors altogether in annular spaces. Heck, eliminate them everywhere. They are only good for sumps and containment areas that are so poorly constructed that liquid intrusion is a constant problem. Repairing the sumps would be a better solution to liquid intrusion problems.
- The positive shut down sump sensors are plastic and they stick open. Some type of new stick product is needed.
- You might want to require that all sensors be replaced regularly every 2-3 years.
- Eliminate discriminating sensors unless they have <5sec-response time. They need to be designed so that corrosion and sticking do not occur. Needs to be such that maintenance is minimized since this is only done annually.
- Require quarterly maintenance and inspection of sensors.
- Make them simple and easy to place. The Tri-State feature is best on systems that have no maintenance crew.
- Overall experience with discriminating sensors is minimal, but due to survey set cases/problems, we do not allow or will approve them for use in the city. Result is problematic.
- Better design, stronger materials, and no resistors at sensor end.
- Improve design on brands listed in question 10. Discriminating sensors are not practical. I do not test them due to recovery time. Sometimes they do not recover.
- I don't know if it is possible, but what if they made a sensor that was non-stick so that sludge would not hold the float, making it stuck. The contact points would also need to be sludge proof.
- Better installation practices. Sensors are not being hung at the correct location, i.e. at the bottom of the tank or sump.

- Eliminate discriminating sensors or improve technology. Operate and test sensors under various simulated conditions. Improve technology of annular float sensors in FG tanks to improve accessibility/visual inspection/simulated testing.
- Be there at the annual maintenance checks. You learn a lot, see a lot of the important violations and disrupt the business only once. The entire focus of my inspections is the leak detection systems for piping and tanks. They must work. Operators do not like to do leak detection manually. Pushing toward all electronic monitoring is essential for the future. Get the operators out of it. Have the ATG print out the monthly .2 gph-passing test for tanks at least once a month automatically. Then the operator saves this record for the inspection.
- Testers hate to test the discriminating sensors with product because they know they will have problems getting them cleared, if at all. If the sensors won't clear, then it must be replaced, and tested. On one occasion, the technician did not have a discriminating sensor replacement with him so he had to call his shop and have someone drive one out to the site. This kept that product offline for several hours. The facility operator was not happy.
- Get rid of sacrificial sensors, and require secondary containment for all piping!!!
- My primary objective in completing this survey is to expose the problems that I have encountered in trying to test the sensors for the MSA Tankguard system. All other sensors that I have encountered are sufficiently reliable.
- The compatibility of simple contact switch sensors with the control panels is not a major issue or an operational problem. The use of discriminating sensors is a major issue even when these sensors are used with a compatible control panel.
- We hardly see discriminating sensors. The alarm needs to go through a central alarm system in which case we will know of any release. Tampering defeats the purpose of monitoring. We find improper positioning of the probe/ raised probe 80 % of the sites. Water intrusion a real problem.
- A tank system that is properly constructed and maintained should never have liquid intrusion problems and therefore there is no need for discriminating sensors.
- Owners need a good, simple manual on the tank system components, requirements, and responsibilities: like "straight talk on tanks" in more detail. So many stations change hands and so many employees are clueless, that comprehensive explanation of UST's is desperately needed to start to get an unformed constituency.
- Bravo box float mechanisms for dispenser containment monitoring were not mentioned in this survey but have about a 50% failure rate due to debris or loose chains. SFSFD water tests all float monitored dispenser pans.
- Sensor reliability or rather the lack thereof, has caused local agencies to all other leak detection and testing requirements to UST's. The confidence level in the sensors functioning properly at any given time is low. Because of this the confidence in our UST programs goal of preventing and detecting releases is also somewhat low. Why spend a lot of time and resources when the devices are unreliable? Also, this didn't address mechanical systems. The Bravo Float system has chronic problems with not functioning properly after more than a year. The float does not leave very much room for sidewalls of channels so dirt freezes the movement. Tampering by loosening chains is extremely common. We dislike this design.
- Phasing out existing monitoring systems. I.e. pollulert, petrometer, leak-x, petrovend, etc. Notion current LG-113 should be an eventually to start planning for now.

- Discriminating sensors add approximately 10 min. per sensor for testing and returning to operability. That adds about 2 hours to a standard gas station monitoring certification inspection.
- Question 13(d)- recovery time for diesel fuel is greater than 60 minutes.
- Please remove discriminating sensors from approved method. They are not reliable and/or do not sense for reasonable system monitoring (if located in sump bottom with water in sump a full leak will not be detected if the water level is above the sensor). Question 7-Sensor failure is most common in Tank Top (pump/fill) Sumps and Under Dispenser Containment.
- This survey should allow free-text answers. Some pick-list choices are inadequate. At the very least, there should be a "unknown" response.
- In the past when we arrived on site for an inspection, the maintenance contractor or operator may have already tested and replaced any faulty sensors. This will skew the data you collect from inspectors, indicating higher performance rates.
- People raising probes due to surface water infiltration via rain or steam cleaning the parking lot, which violates many laws.
- Alternate technologies should be available for positive shutdown, which do not rely on the relay boxes.

APPENDIX VI

Field Data

Sensor Field Data Tables

List of Acronyms

Acronym	Meaning
MR	Sensor is manually reset after an alarm
MSA	Mine Safety Appliances
NA	Not applicable to the sensor being tested
NP	Not programmed for pump shut-down
NT	Not tested
PSD	Pump shut-down
Rec	Recovery time (in seconds)
Resp	Response time (in seconds)
UDC	Under-dispenser containment
Unk	Unknown. Data was unavailable

List of Definitions

Term	Definition
Flip Test	Sensor was tested by flipping it over
Heights	All liquid levels are reported in inches
High Test	High-level water testing
Low Test	Low-level water testing. For single-level sensors tested in water, test data will be recorded in this column
Product	Sensor was tested in product
Site ID #200	The 67 sensors tested during Phase I (Veeder-Root discriminating sensors) are included in this database under Site ID# 200
Times	All response and recovery times are reported in seconds

APPENDIX VI, TABLE 1
Summary of All Failures

TABLE 1 - Summary of All Failures

Make Site ID / Model	Discriminating	At Low Point	Wired Properly	Flip Test Result	Flip PSD	Low Test Result	Low PSD	High Test Result	High PSD	Product Result	Product PSD	After testing sensor was
Alpha wire												
92 Unk	<input checked="" type="checkbox"/>	Yes	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Re-Installed
Beaudreau												
82 406	<input type="checkbox"/>	No	Yes	NA	NA	NT	NT	NA	NA	NT	NT	Unk
10 406	<input type="checkbox"/>	Yes	Yes	NA	NA	Fail	NA	NA	NA	NT	NT	Re-Installed
Led indicator light was working on sensor, indicating that the wiring was properly connected. Sensor was reinstalled, meaning local agency has to follow up.												
10 406	<input type="checkbox"/>	Yes	Yes	NA	NA	Fail	NA	NA	NA	NT	NT	Re-Installed
Led indicator light was working on sensor, indicating that the wiring was properly connected. Sensor was reinstalled, meaning local agency has to follow up.												
10 406	<input type="checkbox"/>	Yes	Yes	NA	NA	Fail	NA	NA	NA	NT	NT	Re-Installed
Led indicator light was working on sensor, indicating that the wiring was properly connected. Sensor was reinstalled, meaning local agency has to follow up.												
Gilbarco												
28 PA02591144000	<input type="checkbox"/>	Yes	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Replaced
Sensors was replaced by contractor two days after the inspection.												
28 PA02592000000	<input type="checkbox"/>	Yes	Yes	Fail	No	NT	NT	NA	NA	NT	NT	Replaced
Sensors was replaced by contractor two days after the inspection and positive shut down was rewired.												
28 PA02592000000	<input type="checkbox"/>	Yes	Yes	Fail	No	NT	NT	NA	NA	NT	NT	Replaced
Sensors was replaced by contractor two days after the inspection and positive shut down was rewired.												
98 PA02592000010	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Installed
3-4 inches of water on both sides of sump (low spots of tank top).												
98 PA02592000010	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Installed
2-3 inches of water on both sides of sump (low spots of tank top).												
24 PA02592000010	<input type="checkbox"/>	Yes	Yes	Fail	No	NT	NT	NA	NA	NT	NT	Repaired
Relay was stuck, so the PSD failed when tested. It passed when re-tested.												
Incon												
16 TSP-ULS	<input type="checkbox"/>	No	No	NT	NT	NT	NT	Fail	Yes	NT	NT	Repaired
Sensor was turned off when technician conducted the test. Sensor appears to have been turned due to water in the UDC. After turning the sensor on, it passed.												
35 TSP-ULS	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
The sump was full of diesel approximately 9 1/2 inches deep. The sensor was set at the top of the sump to avoid alarming.												
Mallory Controls												
92 Pollulert MD 241RRA	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	NT	NT	NA	NA	Fail	No	Unk
Sensor failed the test, but the company is out of business. So, owner might have to change the system. Inspector gave the owner two weeks to fix it or replace it.												

All times are recorded in seconds, heights are recorded in inches.

Make	Discriminating	At Low Point	Wired Properly	Flip Test Result	Flip PSD	Low Test Result	Low PSD	High Test Result	High PSD	Product Result	Product PSD	After testing sensor was
Site ID / Model												
MSA												
17 Tankgard 482607	<input type="checkbox"/>	No	No	NA	NA	NT	NT	NA	NA	Fail	Yes	Repaired
Sensor initially turned off. Appears to have been turned off due to product in the sump. Sensor worked when turned on; sensor not at lowest point - about 8" above.												
17 Tankgard 482607	<input type="checkbox"/>	Yes	Yes	NA	NA	NT	NT	NA	NA	Fail	No	Unk
Had to leave site before witnessing removal or re-installation of sensor.												
Red Jacket												
20 Liquid Refraction Sensor	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
Sensor has been pulled up due to high water in the fill/vapor sump.												
Ronan												
20 LS-3	<input type="checkbox"/>	No	Yes	Fail	No	NT	NT	NA	NA	NT	NT	Unk
Sensor appears to be good during a continuity test, but appears not to be hooked up to the control panel.												
47 LS-3	<input type="checkbox"/>	Yes	No	Fail	Yes	NT	NT	NA	NA	NT	NT	Repaired
Sensor would not come out of alarm after testing. Pump would not come on. Contractor repaired the facility. Problem was wiring inside the building, near the control panel.												
20 LS-3	<input type="checkbox"/>	Yes	No	Fail	No	NT	NT	NA	NA	NT	NT	Unk
Sensor appeared to be functional when technician tested for continuity, but did not activate an alarm at the panel. Tech suspects problem with wiring between sensor and panel.												
32 LS-3	<input type="checkbox"/>	Yes	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Repaired
Float was stuck. Technician had to shake it to loosen it, then sensor went into alarm.												
1 LS-7	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
The sensor could not be taken out of the tank interstice; therefore the sensor was activated within the tank.												
Universal												
94 LALS-1	<input type="checkbox"/>	Yes	Yes	Fail	NA	NT	NT	NA	NA	NT	NT	Unk
Contractor waited for 2 minutes for the sensor to response, but never did. Sensor had to be replaced.												
95 LALS-1	<input type="checkbox"/>	Yes	Yes	NA	NA	Fail	No	NA	NA	NT	NT	Unk
Sensor was not tested because it was stuck in the interstitial space.												
94 LAVS-1	<input type="checkbox"/>	Yes	Yes	NA	NA	Fail	No	NA	NA	NT	NT	Unk
Veeder-Root												
85 794380-208	<input type="checkbox"/>	No	Yes	Fail	No	NT	NT	NA	NA	NT	NT	Replaced
The contractor decided to stop testing the sensor after it failed to respond for more than 2 minutes and replace it with a new sensor.												
10 794380-208	<input type="checkbox"/>	No	Yes	Fail	No	NT	NT	NA	NA	NT	NT	Re-Installed
Alarm activated at the control panel, but no pump shutdown. (printer said pump shutdown occurred, but pump continued to run. Picture of sensor is site 7 #2.). Follow up was done on this site and Inspector confirmed that the PSD is functioning properly.												
91 794380-208	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Installed
Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow)												

Make Site ID / Model	Discriminating	At Low Point	Wired Properly	Flip Test Result	Flip PSD	Low Test Result	Low PSD	High Test Result	High PSD	Product Result	Product PSD	After testing sensor was
91 794380-208 Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow)	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Installed
91 794380-208 Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow)	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Installed
91 794380-208 Sensor timed out & Technician had to go and re-set it to shut down the pump.	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Tested
91 794380-208 Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow). Most of sensors timed out & Technician had to go and re-set it to shut down the pump.	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Installed
91 794380-208 Sensor timed out & Technician had to go and re-set it to shut down the pump.	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Tested
91 794380-208 Sensor timed out & Technician had to go and re-set it to shut down the pump.	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Tested
91 794380-208 Sensor timed out & Technician had to go and re-set it to shut down the pump.	<input type="checkbox"/>	No	Yes	NT	NT	Pass	Yes	NA	NA	NT	NT	Re-Tested
42 794380-208 Contains a substantial amount of water.	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
76 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
73 794380-208 Sensor was raised about 4 inches from the bottom of the sump.	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
33 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
33 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
33 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
33 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
33 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
33 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
79 794380-208 Product is leaking out of the top of the turbine pump.	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
79 794380-208 Product is leaking out of the top of the turbine pump.	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
79 794380-208 Product is leaking out of the top of the turbine pump.	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
42 794380-208 The sensor was not located at the lowest point in the tank. Technician lowered it and activetd an alarm.	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed

All times are recorded in seconds, heights are recorded in inches.

Make Site ID / Model	Discriminating	At Low Point	Wired Properly	Flip Test Result	Flip PSD	Low Test Result	Low PSD	High Test Result	High PSD	Product Result	Product PSD	After testing sensor was
76 794380-208	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
62 794380-208 2-3 gallons of product in the sump.	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
62 794380-208 2-3 gallons of product in the sump.	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Re-Installed
42 794380-208	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
85 794380-208 There was a hole in the sump, approximately 1 1/2" diam. Electrical wiring below penetration lines. Hydrostatic test was performed to the highest penetration lines at 16 minutes per cycle. Test at 16 psi and fail if below 12 psi. Fill sump is not clean..	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
10 794380-208 2 sensors, 1 raised in sump and the other was a the lowest point.	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
88 794380-208 Technician waited for over 2 minutes, but sensor did not alarm. Finally inspector decided to call the test off and replace the sensor. Testing was done on the new sensor and it passed.	<input type="checkbox"/>	Yes	Yes	Fail	No	NT	NT	NA	NA	NT	NT	Replaced
200 794380-341	<input checked="" type="checkbox"/>	Unk	Unk	NA	NA	Unk	Unk	NA	NA	Fail	Unk	Unk
200 794380-341	<input checked="" type="checkbox"/>	Unk	Unk	NA	NA	Unk	Unk	NA	NA	Fail	Unk	Unk
19 794380-341 Replaced with same type of sensor.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	NT	NT	NA	NA	Fail	No	Replaced
38 794380-341 Sensor was tested with both unleaded gasoline and waste oil. Both cases, water alarms were observed. Sensor was not approved for use in waste oil. After testing, sensor was replaced and it passed the product test.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	NT	NT	NA	NA	Fail	NA	Replaced
38 794380-341 Sensor sets water alarm for product test. After testing the sensor was replaced and the new sensor was setting the right alarm.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	NA	NA	NA	Fail	No	Replaced
38 794380-341 Sensor sets water alarm for product test. After testing, sensor was replaced and the new sensor was setting the right alarm.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	NA	NA	NA	Fail	No	Replaced
64 794380-341 Detected product as water. Since pump shuts down for product or water, Local Agency did not require sensor to be changed. Owner will replace sensor or re-program as non-discriminating.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	Yes	NA	NA	Fail	Yes	Unk
77 794380-341 Technician had to clean the sensor with a rag completely (especially in the small window at sensor's center) before fuel could be detected. After cleaning sensor did detect fuel.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	Yes	NA	NA	Fail	Yes	Repaired
64 794380-341 Detected product as water. Since pump shuts down for product or water, Local Agency did not require sensor to be changed. Owner will replace sensor or reprogram as non-discriminating.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	Yes	NA	NA	Fail	Yes	Unk
77 794380-341 Technician had to clean the sensor with a rag completely (especially in the small window at sensor's center) before fuel could be detected. After cleaning sensor did detect fuel.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	Yes	NA	NA	Fail	Yes	Repaired
77 794380-341 Technician had to clean the sensor with a rag completely (especially in the small window at sensor's center) before fuel could be detected. After cleaning sensor did detect fuel.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	Yes	NA	NA	Fail	Yes	Repaired
84 794380-350 Sensor did not come out of alarm after being tested in product, so technician replaced it.	<input checked="" type="checkbox"/>	Yes	Yes	NA	NA	Pass	NA	Pass	Yes	Fail	Yes	Replaced

All times are recorded in seconds, heights are recorded in inches.

Make Site ID / Model	Discriminating	At Low Point	Wired Properly	Flip Test Result	Flip PSD	Low Test Result	Low PSD	High Test Result	High PSD	Product Result	Product PSD	After testing sensor was
84 794380-350 Technician suspected a problem with the wiring at this site.	<input checked="" type="checkbox"/>	Yes	Unk	NA	NA	Pass	NA	Fail	No	Fail	No	Re-Installed
84 794380-350 Sensor alarmed, but failed PSD. Problem with the relay is suspected.	<input checked="" type="checkbox"/>	Yes	Unk	NA	NA	Pass	NA	Fail	No	Fail	No	Re-Installed
84 794380-350 Sensor did not respond during high water or product testing. Technician suspected wiring problem, since sensor was replaced but test results did not change.	<input checked="" type="checkbox"/>	Yes	No	NA	NA	Pass	NA	Fail	No	Fail	No	Replaced
22 794380-352 Sensor's low float did not activate (would not reset). Sensor was replaced by the owner without informing the local agency nor the contractor who does the routine inspection. Apparently, they did not retest sensor's functionality.	<input checked="" type="checkbox"/>	No	Yes	NT	NT	Fail	No	Pass	Yes	NT	NT	Re-Installed
200 794380-352	<input checked="" type="checkbox"/>	Unk	Unk	NT	NT	Unk	Unk	Pass	Unk	Fail	Unk	Unk
200 794380-352	<input checked="" type="checkbox"/>	Unk	Unk	NT	NT	Unk	Unk	Pass	Unk	Fail	Unk	
82 794380-352 Wiring malfunctioning.	<input checked="" type="checkbox"/>	Yes	No	NT	NT	NT	NT	NT	NT	NT	NT	Unk
82 794380-352 Wiring malfunctioning.	<input checked="" type="checkbox"/>	Yes	No	NT	NT	NT	NT	NT	NT	NT	NT	Unk
65 794390-205 Sump had oil in it. Sensor was raised above the oil, but alarmed when technician lowered it into the oil. Contractor was notified to pump out the oil that day.	<input type="checkbox"/>	No	Yes	NT	NT	NT	NT	NA	NA	Pass	NA	Re-Installed
46 794390-205 Sensor was raised approximately 1 foot from bottom of the sump.	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
29 794390-407 The sensor was located at the top of the tank, at the access port. The pull-string was broken. Inspector said sensor must be fixed immediately. The sensor was not functionally tested during this inspection. A follow up was done & sensor was repaired.	<input type="checkbox"/>	No	No	NT	NT	NT	NT	NA	NA	NT	NT	Repaired
73 794390-407 Sensor would not go into alarm until the technician shook it vigorously. Float was stuck. Interstice was moist, but not enough liquid to activate an alarm.	<input type="checkbox"/>	Yes	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Repaired
73 794390-407 Sensor would not go into alarm until the technician shook it vigorously. Float was stuck.	<input type="checkbox"/>	Yes	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Repaired
81 794390-409 Sensor was wedged between the primary and secondary tank walls and cannot be removed to verify sensor type. Alarm was not set at the control panel by pulling it like the previous two tanks.	<input type="checkbox"/>	Unk	Unk	Fail	NP	NT	NT	NA	NA	NT	NT	Re-Installed
81 794390-409 Sensor was wedged between the primary and secondary tank walls and cannot be removed to verify sensor type. Alarm was set at the control panel by pulling it. The response time was estimated because there was no way of knowing when sensor was triggered.	<input type="checkbox"/>	Unk	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Re-Installed
51 794390-420 The sensor was missing the float. Follow up was made with local agency and confirmed that the technician repaired the sensor. However, inspector did not perform re-inspection.	<input type="checkbox"/>	NA	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Unk
55 794390-420 This sensor is for steel tanks, and could not be wrapped around the FG tank. Local agency instructed owner to replace.	<input type="checkbox"/>	No	Yes	Pass	NP	NT	NT	NA	NA	NT	NT	Unk

Make	Discriminating	At Low Point	Wired Properly	Flip Test Result	Flip PSD	Low Test Result	Low PSD	High Test Result	High PSD	Product Result	Product PSD	After testing sensor was
Site ID / Model												
89 794390-420	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
Interstitial space is full of water. Technician could not put back the sensor without calling the maintenance to remove water. Sensor was not at lowest point and wire was wrapped up.												
99 794390-420	<input type="checkbox"/>	No	No	Pass	NP	NT	NT	NA	NA	NT	NT	
Waste oil contained oil/water around the tank sump. The sensor was not located in the lowest point.												
89 794390-420	<input type="checkbox"/>	No	Yes	Pass	Yes	NT	NT	NA	NA	NT	NT	Re-Installed
23 794390-420	<input type="checkbox"/>	Yes	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Replaced
Original sensor was stuck in the interstice because of rust on casing; sensor was replaced. New sensor passed test.												
Warrick Controls												
7 DLP-I-NC	<input type="checkbox"/>	Yes	Yes	Fail	NP	NT	NT	NA	NA	NT	NT	Re-Tested
Sensor was sitting in water and not alarmed. Contractor shook sensor and float moved activating the alarm. Sensor passed retest after 1-2 second alarm response.												

APPENDIX VI, TABLE 2
Field Data for Non-discriminating Sensors

TABLE 2 - Field Data for Non-Discriminating Sensor

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Make: Beaudreau															
Sensor Model: 404						Operating Principle: Float Switch									
UDC	Veeder-Root	TLS-300	Yes	Yes	Clean/Dry	3	1	Product	NA	Pass	NT	NT	NT	NT	NT
Sensor Model: 406						Operating Principle: Optical									
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	2	Both	NA	Pass	NA	NA	NA	NA	NA
Sensor shuts off power to dispenser.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	2	Both	NA	Pass	NA	NA	NA	NA	NA
Sensor shuts off power to dispenser.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	2	2	Both	NA	Pass	NA	NA	NA	NA	NA
Sensor shuts off power to dispenser.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	2	2	Both	NA	Pass	NA	NA	NA	NA	NA
Sensor shuts off power to dispenser.															
UDC	Beaudreau	404-4 Cut-off	No	Yes	Debris	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	None	NA	None	NA	Fail	NA	NA	NA	NA	NA
Led indicator light was working on sensor, indicating that the wiring was properly connected. Sensor was reinstalled, meaning local agency has to follow up.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	None	NA	None	NA	Fail	NA	NA	NA	NA	NA
Led indicator light was working on sensor, indicating that the wiring was properly connected. Sensor was reinstalled, meaning local agency has to follow up.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	None	NA	None	NA	Fail	NA	NA	NA	NA	NA
Led indicator light was working on sensor, indicating that the wiring was properly connected. Sensor was reinstalled, meaning local agency has to follow up.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	2	Both	NA	Pass	NA	NA	NA	NA	NA
Sensor shuts off power to dispenser.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	NA	Pass	NA	NA	NA	NA	NA
The sensor was tested in a cup for total darkness and shut off the valve at the dispenser.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	2	5	Both	NA	Pass	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Debris	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
Debris and dust accumulated over the years.															

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	15	1	Both	NA	Pass	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor failed testing 6 weeks earlier. Technician replaced control module (located under dispenser) and now sensor worked.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor failed testing 6 weeks earlier. Technician replaced control module (located under dispenser) and now sensor worked.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor failed testing 6 weeks earlier. Technician replaced control module (located under dispenser) and now sensor worked.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor failed testing 6 weeks earlier. Technician replaced control module (located under dispenser) and now sensor worked.															
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	NA	Pass	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	NA	Pass	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	NA	Pass	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	NA	Pass	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	NA	Pass	NA	NA	NA	NA	NA
UDC	Beaudreau	404-4 Cut-off	Yes	Yes	Clean/Dry	1	1	Both	NA	Pass	NA	NA	NA	NA	NA

Sensor Make: Emco

Sensor Model: Q0003-006

Operating Principle: Optical

Tank Interstice	Emco	EECO 3000	Yes	Yes	Clean/Dry	60	60	Product	NA	Pass	NA	NA	NA	NA	NA
Tank Interstice	Emco	EECO 3000	Yes	Yes	Clean/Dry	60	60	Product	NA	Pass	NA	NA	NA	NA	NA
Tank Interstice	Emco	EECO 3000	Yes	Yes	Clean/Dry	60	60	Product	NA	Pass	NA	NA	NA	NA	NA
Tank Interstice	Emco	EECO 3000	Yes	Yes	Clean/Dry	60	60	Product	NA	Pass	NA	NA	NA	NA	NA

Sensor Model: Q0003-010

Operating Principle: Optical

Pump Sump	Emco Wheaton	Leak Sensor II	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	NA	NA	NA	NP	NA
~8 oz water in cup; panel did not support ATG, only good for open/close sensor response; pressure operating principle?															
Tank Interstice	Emco Wheaton	Leak Sensor II	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
~8 oz water in cup; panel did not support ATG, only good for open/close sensor response; pressure operating principle?															

Sensor Make: Gilbarco

Sensor Model: PA02591144000

Operating Principle: Float Switch

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump Sensor is Gilbarco equivalent of VR model -208.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump Sensor is Gilbarco equivalent of VR model -208.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump Sensor is Gilbarco equivalent of VR model -208.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice Unable to remove and observe waste oil UST overfill sesor. Technician was able to to activate sensor within the tank.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	360	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	720	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Tank Interstice Mid-grade and Premium share the same annular space; some condensation; sensor casing split.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	720	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Tank Interstice Sensors was replaced by contractor two days after the inspection.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	None	NA	None	NP	Fail
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Tank Interstice This was a two-compartment tank (midgrade and premium). The casing of the sensor was split and took the form of a bell.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	8	5	Product	NA	Pass	NT	NT	NT	NT	NT
Tank Interstice Soil in the access area for this sensor was stained dark with diesel fuel from unknown source. Possibly overfill or surface water ingress.	Gilbarco	EMC	Yes	Yes	Clean/Dry	9	5	Product	NA	Pass	NT	NT	NT	NT	NT
Tank Interstice Alarm was set during the removal of the sensor from the tank interstice. Sensor was also covered with dirty water.	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice Sensor is Gilbarco equivalent of VR model -420.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice Sensor is Gilbarco equivalent of VR model -420.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice Sensor is Gilbarco equivalent of VR model -420.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Sensor Model: PA02592000000						Operating Principle: Float Switch									
Pump Sump LLD failed the 3 gph leak test. Needs replacement.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	840	5	Both	NP	Pass
Pump Sump Sensors was replaced by contractor two days after the inspection and positive shut down was rewired.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	No	Fail
Pump Sump Sensors was replaced by contractor two days after the inspection and positive shut down was rewired.	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	No	Fail
Pump Sump	Gilbarco	EMC	Yes	Yes	Product	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	1	Both	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	840	5	Both	NP	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	840	5	Both	NP	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Sensor Model: PA02592000010						Operating Principle: Float Switch									
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Product	NT	NT	NT	NT	NT	10	1	Both	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Product	NT	NT	NT	NT	NT	10	1	Both	Yes	Pass
Pump Sump Relay was stuck, so the PSD failed when tested. It passed when re-tested.	Gilbarco	EMC	Yes	Yes	Product	NT	NT	NT	NT	NT	30	1	Both	No	Fail
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	No	Yes	Water	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
3-4 inches of water on both sides of sump (low spots of tank top).															
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	7	10	Product	Yes	Pass
Flip test used since cable was too short to remove from sump for water test.															
Pump Sump	Gilbarco	EMC	No	Yes	Water	8	8	Product	Yes	Pass	NT	NT	NT	NT	NT
2-3 inches of water on both sides of sump (low spots of tank top).															
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Sensor Model: PA0259300000-2				Operating Principle: Float Switch											
Tank Interstice	Gilbarco	EMC	NA	Yes	Brine-Filled	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump shut down on high and low level alarms.															
Tank Interstice	Gilbarco	EMC	NA	Yes	Brine-Filled	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump shut down on high and low level alarms.															
Sensor Make: Incon															
Sensor Model: TS-ILS				Operating Principle: Optical											
Tank Interstice	Incon	1000ER	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
Sensor Model: TSP-HIS				Operating Principle: Float Switch											
Tank Interstice	Incon	TS-1000	Yes	Yes	Brine-Filled	NT	NT	NT	NT	NT	15	Unk	Product	NP	Pass
The sensor is Incon (double floats) continuously monitors the interstitial space.It was tested for both high level and low level alarms.															
Tank Interstice	Incon	TS-1000	Yes	Yes	Brine-Filled	NT	NT	NT	NT	NT	10	Unk	Product	NP	Pass
Sensor Model: TSP-ULS				Operating Principle: Float Switch											
Fill Sump	Incon	TS-1000	No	Yes	Product	NT	NT	NT	NT	NT	1	15	Product	Yes	Pass
The sump was full of diesel approximately 9 1/2 inches deep. The sensor was set at the top of the sump to avoid alarming.															
Fill Sump	Incon	TS-1000EFI	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Both	Yes	Pass
Pump Sump	Incon	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Small metal casing with holes at bottom of sensor for liquid to enter; console had printer and ATG capability.															

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Incon	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Small metal casing with holes at bottom of sensor for liquid to enter; console had printer and ATG capability.															
Pump Sump	Incon	1000ER	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Pump Sump	Incon	TS-1000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	NP	Pass
This facility does not have a positive shut-down feature.															
Pump Sump	Incon	TS-1000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	NP	Pass
Pump Sump	Incon	TS-1000EFI	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	25	Unk	Both	Yes	Pass
Pump Sump	Incon	TS-1000	Yes	Yes	Water	NT	NT	NT	NT	NT	1	15	Product	Yes	Pass
Tank Interstice	Incon	1000ER	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Tank Interstice	Incon	TS-1000	NA	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	15	Product	Yes	Pass
Tank Interstice	Incon	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Small metal casing with holes at bottom of sensor for liquid to enter; console had printer and ATG capability.															
Tank Interstice	Incon	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Small metal casing with holes at bottom of sensor for liquid to enter; console had printer and ATG capability.															
UDC	Incon	TS-1000	Yes	Yes	Product	NT	NT	NT	NT	NT	1	15	Product	Yes	Pass
There was a substantial amount of product in the UDC. There seemed to be a leak in the piping under the dispenser. It was in alarm on arrival.															
UDC	Incon	1000ER	No	No	Water	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sensor was turned off when technician conducted the test. Sensor appears to have been turned due to water in the UDC. After turning the sensor on, it passed.															

Sensor Make: MSA

Sensor Model: Tankgard 482607						Operating Principle: Thermal Conductivity									
Pump Sump	MSA	Tankguard	Yes	Yes	Water	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
Pump Sump	MSA	Tankguard	No	No	Water	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
Sensor initially turned off. Appears to have been turned off due to product in the sump. Sensor worked when turned on; sensor not at lowest point - about 8" above.															
Pump Sump	MSA	Tankguard	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
Had to leave site before witnessing removal or re-installation of sensor.															
Tank Interstice	MSA	Tankguard	Unk	Unk	Water	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
Sensor also is monitoring the presense of antifreeze, which shared the tank with the waste oil.															
Tank Interstice	MSA	Tankguard	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA

Sensor Make: Owens-Corning Tank

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Model: FHRB 810			Operating Principle: Float Switch												
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	NT	NT	NT	NT	NT	20	Unk	Both	NP	Pass
This single sensor monitors the regular-mid-premium tanks; two reservoirs are used (left and right) and both must be activated for the alarm to go off.															
Sensor Make: PermAlert															
Sensor Model: PSTV			Operating Principle: Float Switch												
Tank Interstice	Red Jacket	PPM 4000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	Unk	Both	Yes	Pass
Sensor Make: Pneumeractor															
Sensor Model: LS 600LD			Operating Principle: Float Switch												
Pump Sump	Pneumeractor	LC-1000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Unknown sensor type, photo taken. Flip test was done because sensor wiring prevented removal of the sensor (wiring too short).															
Pump Sump	Pneumeractor	LC-1000	Unk	Yes	Water	NT	NT	NT	NT	NT	2	Unk	Product	NP	Pass
Water in sumps was below level of the sensor. Flip test was done due to wiring being too short. No labels or markings on the sensor. Picture was taken.															
Pump Sump	Pneumeractor	LC-1000	Unk	Yes	Water	NT	NT	NT	NT	NT	2	Unk	Product	NP	Pass
Sensor Make: Red Jacket															
Sensor Model: Liquid Refraction Sensor			Operating Principle: Optical												
Fill Sump	Red Jacket	PPM 4000	No	Yes	Water/Debris	NT	NT	NT	NT	NT	2	Unk	Both	Yes	Pass
Sensor has been pulled up due to high water in the fill/vapor sump.															
Sensor Model: RE400-111-5			Operating Principle: Float Switch												
Pump Sump	Red Jacket	STL 1801	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Red Jacket	STL 1401	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Red Jacket	STL 1401	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Red Jacket	STL 1801	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Red Jacket	STL 1401	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Red Jacket	STL 1801	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Sensor Model: Unk			Operating Principle: Float Switch												
Pump Sump	Veeder-Root	TLS-300	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Make: Ronan															
Sensor Model: LS-3															
Operating Principle: Float Switch															
Fill Sump	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Fail
Float was stuck. Technician had to shake it to loosen it, then sensor went into alarm.															
Fill Sump	Ronan	X761VCS-3LXi	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Fill Sump	Ronan	X761VCS-3LXi	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Fill Sump	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Fill Sump	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Fill Sump	Ronan	X76S	Yes	Yes	Water	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Slight amount of water in fill sump. Not enough to activate an alarm.															
Fill Sump	Ronan	X761VCS-3LXi	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Fill Sump	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Fill Sump	Red Jacket	PPM 4000	No	Yes	Water/Debris	NT	NT	NT	NT	NT	Unk	Unk	None	No	Fail
Sensor appears to be good during a continuity test, but appears not to be hooked up to the control panel.															
Monitoring Well	EBW	AutoStik Jr. 4	Yes	Yes	Backfill	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Sensor is a custom version of the LS3-A. It is made of stainless steel and is resistant to the chemicals stored in the system.															
Monitoring Well	EBW	AutoStik Jr. 4	Yes	Yes	Backfill	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Sensor is a custom version of the LS3-A. It is made of stainless steel and is resistant to the chemicals stored in the system.															
Monitoring Well	EBW	AutoStik Jr. 4	Yes	Yes	Backfill	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Sensor is a custom version of the LS3-A. It is made of stainless steel and is resistant to the chemicals stored in the system.															
Monitoring Well	EBW	AutoStik Jr. 4	Yes	Yes	Backfill	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Sensor is a custom version of the LS3-A. It is made of stainless steel and is resistant to the chemicals stored in the system.															
Monitoring Well	EBW	AutoStik Jr. 4	Yes	Yes	Backfill	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Sensor is a custom version of the LS3-A. It is made of stainless steel and is resistant to the chemicals stored in the system.															
Monitoring Well	EBW	AutoStik Jr. 4	Yes	Yes	Backfill	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Sensor is a custom version of the LS3-A. It is made of stainless steel and is resistant to the chemicals stored in the system.															

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Ronan	X76S	Yes	Yes	Water	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Pump Sump	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Fail-safe was verified operational.															
Pump Sump	Ronan	X76VS	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	1	Product	Yes	Pass
Pump Sump	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Fail-safe was verified operational.															
Pump Sump	Ronan	X76S	Yes	No	Clean/Dry	NT	NT	NT	NT	NT	3	NA	Product	Yes	Fail
Sensor would not come out of alarm after testing. Pump would not come on. Contractor repaired the facility. Problem was wiring inside the building, near the control panel.															
Pump Sump	Ronan	X76S	Yes	Yes	Water	NT	NT	NT	NT	NT	1	1	Both	Yes	Pass
Pump Sump	Ronan	X76S	Yes	Yes	Water	NT	NT	NT	NT	NT	1	1	Both	Yes	Pass
Pump Sump	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Fail-safe was verified operational.															
Pump Sump	Red Jacket	PPM 4000	Yes	No	Water	NT	NT	NT	NT	NT	none	NA	None	No	Fail
Sensor appeared to be functional when technician tested for continuity, but did not activate an alarm at the panel. Tech suspects problem with wiring between sensor and panel.															
Pump Sump	Ronan	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Unk	NP	Pass
This site has a suction system and a tank sump.															
Pump Sump	Ronan	X761VCS-3LXi	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Pump Sump	Red Jacket	PPM 4000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	Unk	Both	Yes	Pass
After follow up with local agency, inspector confirmed that the technician replaced fill sump sensor and replaced the broken wire in the monitor.															
Pump Sump	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Pump Sump	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Pump Sump	Ronan	X76VS	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	1	Product	Yes	Pass
Pump Sump	Ronan	X76S	Yes	Yes	Water	NT	NT	NT	NT	NT	1	2	Both	NP	Pass
Pump Sump	Ronan	X76S	Yes	Yes	Water	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Pump Sump	Ronan	X76VS	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	1	Product	Yes	Pass
Sensor was on its side and slightly upside-down, but not in alarm. Sensor did alarm when fully flipped over. Tech re-installed sensor properly after testing.															
Pump Sump	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Pump Sump	Ronan	X761VCS-3LXi	Yes	Yes	Water	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Pump Sump	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Ronan	X76S	Yes	Yes	Water	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Pump Sump	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Pump Sump	Ronan	X761VCS-3LXi	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Pump Sump	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Tank Interstice	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Red Jacket	PPM 4000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	Unk	Both	Yes	Pass
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	11	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
UDC	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
<hr/>															
Sensor Model: LS-30				Operating Principle: Float Switch											
Tank Interstice	Ronan	X76S	NA	Yes	Brine-Filled	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Tank Interstice	Ronan	X76S	NA	Yes	Brine-Filled	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Tank Interstice	Ronan	Unk	NA	Yes	Unk	3	3	Water	NA	Pass	NT	NT	NT	NT	NT
Ronan- LS-30 hydrostatic in generator tank.															
Tank Interstice	Ronan	X76S	NA	Yes	Brine-Filled	NT	NT	NT	NT	NT	2	2	Both	NP	Pass
Tank Interstice	Ronan	X76S	NA	Yes	Brine-Filled	NT	NT	NT	NT	NT	2	2	Both	NP	Pass

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Model: LS-7			Operating Principle: Float Switch												
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Technician pulled wire and pull string at the same time. This lifts the sensor off the bottom of the tank interstice and allows the float to fall, activating the alarm.															
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Technician pulled wire and pull string at the same time. This lifts the sensor off the bottom of the tank interstice and allows the float to fall, activating the alarm.															
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Technician pulled wire and pull string at the same time. This lifts the sensor off the bottom of the tank interstice and allows the float to fall, activating the alarm.															
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	1	Product	NP	Pass
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	1	Product	NP	Pass
Tank Interstice	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	4	Product	NP	Pass
Tank Interstice	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Ronan	X76VS	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Alarm was activated by shaking sensor while still in tank interstice.															
Tank Interstice	Ronan	X76LVC	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
The sensor could not be taken out of the tank interstice; therefore the sensor was activated within the tank.															
Tank Interstice	Ronan	X76VS	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Sensor had to be re-installed with a fish-tape because the string was broken. This took the contractor about 1 hour.															
Tank Interstice	Ronan	X76S	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	1	Product	NP	Pass
Tank Interstice	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Ronan	X76VS	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Alarm was activated by shaking sensor while still in tank interstice.															
Tank Interstice	Ronan	X76LVC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Product	NP	Pass
Tank Interstice	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Ronan	X76-4X	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Ronan	X76LVC	NA	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Ronan	X76VS	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Alarm was activated by shaking sensor while still in tank interstice.															
Sensor Model: Unk			Operating Principle: Float Switch												
Tank Interstice	Veeder-Root	TLS-300	NA	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Make: Universal															
Sensor Model: LALS-1						Operating Principle: Thermal Conductivity									
Fill Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	1	Unk	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor activates an audible alarm and shuts down pump at the dispenser.															
Fill Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	1	Unk	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor activates an audible alarm and shuts down pump at the dispenser.															
Piping Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	1	Unk	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor activates an audible alarm and shuts down pump at the dispenser.															
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	Unk	Product	NA	Pass	NA	NA	NA	NA	NA
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	3	2	Water	Yes	Pass	NA	NA	NA	NA	NA
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	2	Water	Yes	Pass	NA	NA	NA	NA	NA
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Vapor Odor	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Contractor blows on the sensor to activate the alarm. Sensor responds instantly. Sumps had been recently refinished and had strong chemical smell, not fuel.															
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	Unk	Product	NA	Pass	NA	NA	NA	NP	NA
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Vapor Odor	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Contractor blows on the sensor to activate the alarm. Sensor responds instantly. Sumps had been recently refinished and had strong chemical smell, not fuel.															
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	Unk	Product	NA	Pass	NA	NA	NA	NA	NA
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	8	10	Water	Yes	Pass	NA	NA	NA	NA	NA
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	15	15	Water	NA	Pass	NA	NA	NA	NA	NA
Emergency generator with 1000 gallon tank.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	5	3	Water	Yes	Pass	NA	NA	NA	NA	NA
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	4	4	Water	Yes	Pass	NA	NA	NA	NA	NA
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Water	NA	Pass
Contractor blows on the sensor to activate the alarm.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NA	Pass
Contractor blows on the sensor to activate the alarm. Sensor responds instantly.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NA	Pass
Contractor blows on the sensor to activate the alarm. Sensor responds instantly.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NA	Pass
Contractor blows on the sensor to activate the alarm. Sensor responds instantly.															

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	Unk	Product	NA	Pass	NA	NA	NA	NA	NA
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	Unk	Product	NA	Pass	NA	NA	NA	NA	NA
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Both	NA	Pass
Contractor blows on the sensor to activate the alarm.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Water	NA	Pass
Contractor blows on the sensor to activate the alarm.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	3	3	None	Yes	Pass	NA	NA	NA	NA	NA
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Water	NA	Pass
Contractor blows on the sensor to activate the alarm.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	1	Unk	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor activates an audible alarm and shuts down pump at the dispenser.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	1	Unk	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor activates an audible alarm and shuts down pump at the dispenser.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	None	None	None	NA	Fail
Contractor waited for 2 minutes for the sensor to response, but never did. Sensor had to be replaced.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	None	NA	None	No	Fail	NA	NA	NA	NA	NA
Sensor was not tested because it was stuck in the interstitial space.															
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	Unk	Product	NA	Pass	NA	NA	NA	NA	NA
Sensor Model: LAVS-1				Operating Principle: Metal Oxide Semiconductor											
Tank Interstice	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	Unk	Unk	Unk	No	Fail	NA	NA	NA	NA	NA
Sensor Model: LS 03875 STP Sensor				Operating Principle: Thermal Conductivity											
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	33	Product	Yes	Pass	NA	NA	NA	NP	NA
There was no light bulb on the monitoring panel, but alarm activated.															
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	11	Product	Yes	Pass	NA	NA	NA	NA	NA
There was no light bulb on the monitoring panel, but alarm activated.															
Pump Sump	Universal	Leak Alert LA-08	Yes	Yes	Clean/Dry	2	15	Product	Yes	Pass	NA	NA	NA	NP	NA
There was no light bulb on the monitoring panel, but alarm activated.															
Sensor Make: Veeder-Root															
Sensor Model: 330212-001				Operating Principle: Float Switch											
UDC	Veeder-Root	Dispenser cut-off	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
UDC	Veeder-Root	Dispenser cut-off	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	MR	Both	NP	Pass
Sensor cuts power to dispenser, which must be manually reset.															
UDC	Veeder-Root	Dispenser cut-off	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	1	Product	Yes	Pass
UDC	Veeder-Root	Dispenser cut-off	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
UDC	Veeder-Root	Dispenser cut-off	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
UDC	Veeder-Root	Dispenser cut-off	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	MR	Both	NP	Pass
Sensor cuts power to dispenser, which must be manually reset.															
UDC	Veeder-Root	Dispenser cut-off	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	MR	Both	NP	Pass
Sensor cuts power to dispenser, which must be manually reset.															
Sensor Model: 331102-002 Operating Principle: Float Switch															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	1	Both	Yes	Pass
Sensor has double float alarm (high/low). Service technician decided only to do the flip test.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Both	Yes	Pass
Sensor has double float alarm (high/low). Service technician decided only to do the flip test.															
Sensor Model: 794380-208 Operating Principle: Float Switch															
ATG Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Sump contains dirty water. Alarm was set at the control panel.															
ATG Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Sump contains dirty water. Alarm was set at the control panel.															
ATG Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Sump contains dirty water. Alarm was set at the control panel.															
ATG Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
ATG Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
ATG Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	3	3	Product	Yes	Pass
Fill sump contains water, dirt, and corrosion.															
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Debris	NT	NT	NT	NT	NT	3	2	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Product	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Sensor was in alarm when technician arrived to conduct inspection. Technician called to have the product removed.															
Fill Sump	Veeder-Root	TLS-350	No	Yes	Water	NT	NT	NT	NT	NT	2	2	Product	NP	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Fill Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	10	2	Product	Yes	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Debris	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	Unk	Product	NA	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Product	NT	NT	NT	NT	NT	8	Unk	Product	NP	Pass
Fill sump contains waste oil.															
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Product	NT	NT	NT	NT	NT	8	Unk	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Product	NT	NT	NT	NT	NT	8	Unk	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Product	NT	NT	NT	NT	NT	8	Unk	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	10	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	8	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Fill Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	none	NA	None	No	Fail
Technician waited for over 2 minutes, but sensor did not alarm. Finally inspector decided to call the test off and replace the sensor. Testing was done on the new sensor and it passed.															
Fill Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Fill Sump	Veeder-Root	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	6	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	12	2	Product	Yes	Pass
Fill Sump	Veeder-Root	TLS-350	No	Yes	Water	NT	NT	NT	NT	NT	15	1	Product	Yes	Pass
The sensor was not located at the lowest point in the tank. Technician lowered it and activated an alarm.															
Fill Sump	Veeder-Root	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	5	6	Product	Yes	Pass

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Fill Sump Contains a substantial amount of water.	Veeder-Root	TLS-350	No	Yes	Water	NT	NT	NT	NT	NT	5	1	Product	NP	Pass
Fill Sump	Veeder-Root	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	6	Product	Yes	Pass
Fill Sump The sensor was not at the lowest point in the tank.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Fill Sump Sump has 4-5 inches of water. Technician was waiting for maintenance to clean the water before putting back the sensor.	Veeder-Root	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Fill Sump Sump has 4-5 inches of water. Technician was waiting for maintenance to clean the water before putting back the sensor.	Veeder-Root	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Piping Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
Pump Sump Alarm was set at the control panel.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	5	2	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	5	2	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	5	2	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump Flip Test- estimated response of 10 seconds.	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Pump Sump Flip Test- estimated response of 10 seconds	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Pump Sump Alarm was set at the control panel.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	6	2	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Product	NT	NT	NT	NT	NT	5	2	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	5	Product	Yes	Pass
Pump Sump The cable is too short to test sensor in liquid, Instead perform a flip test.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Flip Test- estimated response of 10 seconds															
Pump Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	10	4	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	12	4	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Alarm was set at the control panel.															
Pump Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	4	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	10	4	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Pump Sump	Unk	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	6	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	Unk	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	Unk	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	8	4	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	15	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	7	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	10	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Cable was too short to allow for testing in liquid. Flip test was used.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Cable was too short to allow for testing in liquid. Flip test was used.															

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Cable was too short to allow for testing in liquid. Flip test was used.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	Unk	Pass
Tested 4 of VR 208 sensors, all 4 alarms were set.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	Unk	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	Unk	Pass
Pump Sump	Veeder-Root	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	5	6	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	15	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	3	3	Product	NP	Pass
2-3 gallons of product in the sump. Sensor was raised above the product level. Sensor in pump sump was not programmed to shut down pump.															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	25	17	Water	Yes	Pass	NT	NT	NT	NT	NT
Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow)															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	20	20	Water	Yes	Pass	NT	NT	NT	NT	NT
Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow)															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	20	20	Water	Yes	Pass	NT	NT	NT	NT	NT
Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow)															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	20	15	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump.															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	25	30	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump.															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	20	30	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump.															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	20	20	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump.															
Pump Sump	Veeder-Root	Unk	No	Yes	Water	20	15	Water	Yes	Pass	NT	NT	NT	NT	NT
Fill bucket was detached. Stick was in the product line (to prevent the flapper from shutting down the flow). Most of sensors timed out & Technician had to go and re-set it to shut down the pump.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	Unk	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	No	Yes	Water	NT	NT	NT	NT	NT	2	Unk	Product	Yes	Pass
2 sensors, 1 raised in sump and the other was a the lowest point. Both responded and activated pump shut off. Picture of sensor was taken.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	2	Unk	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	15	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Sensor was raised about 4 inches from the bottom of the sump.															
Pump Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	3	3	Product	NP	Pass
2-3 gallons of product in the sump. Sensor was raised above the product level. Sensor in pump sump was not programmed to shut down pump.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	10	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	12	10	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	8	10	Product	Yes	Pass
Product is leaking out of the top of the turbine pump.															
Pump Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	8	10	Product	Yes	Pass
Product is leaking out of the top of the turbine pump.															
Pump Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	8	10	Product	Yes	Pass
Product is leaking out of the top of the turbine pump.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	Unk	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	Unk	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	15	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	4	Product	Yes	Pass
Noticed a 1" hole in the sump, which will need to be repaired in order to have tight secondary containment.															
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-300	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	30	Unk	Product	NP	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	5	Product	Yes	Pass
There was a hole in the sump, approximately 1 1/2" diam. Electrical wiring below penetration lines. Hydrostatic test was performed to the highest penetration lines at 16 minutes per cycle. Test at 16 psi and fail if below 12 psi. Fill sump is not clean..															
Pump Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	er 2 m	NA	None	No	Fail
The contractor decided to stop testing the sensor after it failed to respond for more than 2 minutes and replace it with a new sensor.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	4	NA	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Product	Yes	Pass
Pump Sump	Unk	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	4	Product	Yes	Pass
Pump Sump	Veeder-Root	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	8	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Both	NP	Pass
Pump Sump	Veeder-Root	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Sump has 4-5 inches of water. Technician was waiting for maintenance to clean the water before putting back the sensor.															
Pump Sump	Veeder-Root	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Sump has 4-5 inches of water. Technician was waiting for maintenance to clean the water before putting back the sensor.															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	15	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	Unk	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	10	5	Product	Yes	Pass	NT	NT	NT	NT	NT
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	15	10	Product	Yes	Pass	NT	NT	NT	NT	NT
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	15	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	15	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	15	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	Unk	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	Unk	Pass

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	Unk	Pass
Tested six dispensers, all passed-alarms set (total of six triggers), all six sensors (VR 208) are working.															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Flip Test- estimated response of 10 seconds															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	2	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	15	10	Product	Yes	Pass	NT	NT	NT	NT	NT
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	10	5	Product	Yes	Pass	NT	NT	NT	NT	NT
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Flip Test- estimated response of 10 seconds															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Flip Test- estimated response of 10 seconds															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NA	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	4	Product	Yes	Pass
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	20	20	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump. Technician conducts water and flip test in some of the sensors because the wire did not reach te water bucket.															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	Unk	Pass
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	20	25	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump. Technician conducts water and flip test in some of the sensors because the wire did not reach te water bucket.															
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	22	22	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump. Technician conducts water and flip test in some of the sensors because the wire did not reach the water bucket.															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	Unk	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	22	22	Water	Yes	Pass	NT	NT	NT	NT	NT
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	21	21	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump. Technician conducts water and flip test in some of the sensors because the wire did not reach te water bucket.															
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	25	22	Water	Yes	Pass	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump. Technician conducts water and flip test in some of the sensors because the wire did not reach te water bucket.															
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	22	22	Water	Yes	Pass	NT	NT	NT	NT	NT
UDC	Veeder-Root	Unk	Yes	Yes	Clean/Dry	20	20	Unk	Unk	Unk	NT	NT	NT	NT	NT
Sensor timed out & Technician had to go and re-set it to shut down the pump. Technician conducts water and flip test in some of the sensors because the wire did not reach te water bucket.															
Unk	Veeder-Root	TLS-350	No	Yes	Water	NT	NT	NT	NT	NT	2	2	Product	No	Fail
Alarm activated at the control panel, but no pump shutdown. (printer said pump shutdown occurred, but pump continued to run. Picture of sensor is site 7 #2.). Follow up was done on this site and Inspector confirmed that the PSD is functioning properly.															
Vault	Gilbarco	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Single wall steel tank inside a Vault. Vapor recovery fill bucket is half way full of water.															
Sensor Model: 794380-209					Operating Principle: Float Switch										
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	12	Unk	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	12	Unk	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	12	Unk	Product	Yes	Pass
Sensor Model: 794380-300					Operating Principle: Float Switch										
Tank Interstice	Veeder-Root	TLS-300	NA	Yes	Brine-Filled	2	2	Water	NA	Pass	NT	NT	NT	NT	NT
Sensor Model: 794380-301					Operating Principle: Float Switch										
Tank Interstice	Veeder-Root	Simplicity	Yes	Yes	Brine-Filled	NT	NT	NT	NT	NT	6	1	Both	Yes	Pass
Tank Interstice	Veeder-Root	Simplicity	Yes	Yes	Brine-Filled	NT	NT	NT	NT	NT	6	1	Both	Yes	Pass
Tank Interstice	Veeder-Root	Simplicity	Yes	Yes	Brine-Filled	NT	NT	NT	NT	NT	6	1	Both	Yes	Pass
Sensor Model: 794380-302					Operating Principle: Float Switch										
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	20	15	Water	NA	Pass	NT	NT	NT	NT	NT
Technician lifted sensor out of brine reservoir to activate the "low water level" alarm.															
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	10	Unk	Low Brine Level	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	10	Unk	Low Brine Level	Yes	Pass	NT	NT	NT	NT	NT

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	20	15	Water	NA	Pass	NT	NT	NT	NT	NT
Technician lifted sensor out of brine reservoir to activate the "low water level" alarm.															
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	30	10	Water	NA	Pass	NT	NT	NT	NT	NT
Technician lifted sensor out of brine reservoir to activate the "low water level" alarm.															
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	10	Unk	Low Brine Level	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Brine-Filled	30	10	Water	NA	Pass	NT	NT	NT	NT	NT
Technician lifted sensor out of brine reservoir to activate the "low water level" alarm.															
Sensor Model: 794380-408						Operating Principle: Float Switch									
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	Unk	Product	NP	Pass
Alarm set at the control panel, sensor is not programmed for pump shut down or dispenser shut down.															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	Unk	Product	NP	Pass
Alarm set at the control panel, sensor is not programmed for pump shut down or dispenser shut down.															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	Unk	Product	NP	Pass
Alarm set at the control panel, sensor is not programmed for pump shut down or dispenser shut down.															
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	6	Unk	Product	NP	Pass
Alarm set at the control panel, sensor is not programmed for pump shut down or dispenser shut down.															
Sensor Model: 794380-500						Operating Principle: Float Switch									
Tank Interstice	Veeder-Root	TLS-300	NA	Yes	Brine-Filled	2	2	Water	NA	Pass	NT	NT	NT	NT	NT
Sensor Model: 794390-205						Operating Principle: Float Switch									
Fill Sump	Veeder-Root	TLS-350	No	Yes	Product	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sump had oil in it. Sensor was raised above the oil, but alarmed when technician lowered it into the oil. Contractor was notified to pump out the oil that day.															
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	NA	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	NA	Pass	NT	NT	NT	NT	NT
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	NP	Pass
Fill Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	Yes	Pass
Sensor was Gilbarco equivalent of Veeder Root Model 794380-205. Cable was too short to test the sensor in liquid, so flip test was used.															
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	6	Product	NP	Pass
Fill Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	6	Product	NP	Pass

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Fill Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Sensor was Gilbarco equivalent of Veeder Root Model 794380-205. Cable was too short to test the sensor in liquid, so flip test was used.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	90	Unk	Product	NP	Pass
sensor is not programmed for positive shut down, only sets an audible alarm.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	8	6	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	6	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	25	5	Both	Yes	Pass
Some condensation on sump.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	90	Unk	Product	NP	Pass
sensor is not programmed for positive shut down, only sets an audible alarm.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	10	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	90	Unk	Product	NP	Pass
sensor is not programmed for positive shut down, only sets an audible alarm.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	5	Both	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Product	NT	NT	NT	NT	NT	5	1	Both	NP	Pass
1 inch of kerosene in sump; this sensor was tested with just an alarm first; retesting while running pump and the pump did not shut off.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	20	5	Both	Yes	Pass
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	Yes	Pass
Sensor was Gilbarco equivalent of Veeder Root Model 794380-205. Cable was too short to test the sensor in liquid, so flip test was used.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	20	10	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	5	Both	Yes	Pass
For this tank, there are two sumps, but only one sensor (the sumps are linked).															
Pump Sump	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Sensor was Gilbarco equivalent of Veeder Root Model 794380-205. Cable was too short to test the sensor in liquid, so flip test was used.															
Pump Sump	Veeder-Root	TLS-350	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	10	Product	Yes	Pass
Sensor was raised approximately 1 foot from bottom of the sump.															
Pump Sump	Veeder-Root	TLS-350	Unk	Yes	Water	NT	NT	NT	NT	NT	1	2	Product	Yes	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Veeder-Root	TLS-350	Unk	Yes	Water	NT	NT	NT	NT	NT	5	2	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	10	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	1	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	1	Product	Yes	Pass
Tank Interstice Diesel tank interstice 50m from sump.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	20	5	Both	Yes	Pass
Tank Sump Suction system with tank top sump.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	25	Unk	Product	NP	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	1	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	1	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	1	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	1	Product	Yes	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	1	Product	Yes	Pass
Sensor Model: 794390-407						Operating Principle: Float Switch									
Tank Interstice The sensor was located at the top of the tank, at the access port. The pull-string was broken. Inspector said sensor must be fixed immediately. The sensor was not functionally tested during this inspection. A follow up was done & sensor was repaired.	Veeder-Root	TLS-350	No	No	Clean/Dry	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice Wrap-around sensor. Techician moved sensor toward top of tank until alarm sounded. Did not completely remove the sensor.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice Wrap-around sensor. Techician moved sensor toward top of tank until alarm sounded. Did not completely remove the sensor.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice Wrap-around sensor. Techician moved sensor toward top of tank until alarm sounded. Did not completely remove the sensor.	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Unk	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice Sensor would not go into alarm until the technician shook it vigorously. Float was stuck. Interstice was moist, but not enough liquid to activate an alarm.	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	5	5	Product	NP	Fail

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Technician pulled sensor around the tank until alarm activated, but did not fully remove the sensor from the annular space.															
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	10	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Alarm was set during the removal of the sensor from the tank interstice.															
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	15	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	Unk	Unk	Product	NP	Pass
Alarm was set during the removal of the sensor from the tank interstice.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Unk	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Technician pulled sensor around the tank until alarm activated, but did not fully remove the sensor from the annular space.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Fail
Sensor would not go into alarm until the technician shook it vigorously. Float was stuck.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Technician pulled sensor around the tank until alarm activated, but did not fully remove the sensor from the annular space.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Unk	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Technician pulled sensor around the tank until alarm activated, but did not fully remove the sensor from the annular space.															
Sensor Model: 794390-409 Operating Principle: Float Switch															
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	2	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Unk	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Unk	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Unk	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	9	Unk	Product	NP	Pass
Sensor is not set up for pump shut down.															
Tank Interstice	Veeder-Root	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	17	17	Product	Yes	Pass
Three tanks (1 split gasoline tank & 2 diesel tanks)															
Tank Interstice	Veeder-Root	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	20	20	Product	Yes	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice	Veeder-Root	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	20	20	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	NP	Pass
Tested 4 of 409 sensors, all appeared to be dry and clean; alarms set for all sensors.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Unk	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Flip Test - Approximately 10 Seconds.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Unk	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Flip Test - Approximately 10 Seconds.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	15	Unk	Product	Unk	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	9	Unk	Product	NP	Pass
Sensor is not set up for pump shut down.															
Tank Interstice	Veeder-Root	TLS-350	Unk	Yes	Clean/Dry	NT	NT	NT	NT	NT	75	Unk	Product	NP	Fail
Sensor was wedged between the primary and secondary tank walls and cannot be removed to verify sensor type. Alarm was set at the control panel by pulling it. The response time was estimated because there was no way of knowing when sensor was triggered.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	45	Unk	Product	NP	Pass
Follow up was made on this site with the local agnecy and assured that next day, the contractor replaced the broken sensors. Inspector did not re-inspect, but received a report from the contractor indicating that the sensor is working properly.															
Tank Interstice	Veeder-Root	TLS-350	Unk	Unk	Clean/Dry	NT	NT	NT	NT	NT	None	Unk	None	NP	Fail
Sensor was wedged between the primary and secondary tank walls and cannot be removed to verify sensor type. Alarm was not set at the control panel by pulling it like the previous two tanks.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Unk	NT	NT	NT	NT	NT	10	10	Product	NP	Pass
Flip Test - Approximately 10 Seconds.															
Sensor Model: 794390-420															
Operating Principle: Float Switch															
Piping Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
3 small steel pipes (1 for each generator) were run within one large steel pipe. The sensor monitors the large pipe, which stays dry unless the small pipes leak.															
Piping Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
3 small steel pipes (1 for each generator) were run within one large steel pipe. The sensor monitors the large pipe, which stays dry unless the small pipes leak.															
Piping Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
3 small steel pipes (1 for each generator) were run within one large steel pipe. The sensor monitors the large pipe, which stays dry unless the small pipes leak.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	No	No	Water	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Waste oil contained oil/water around the tank sump. The sensor was not located in the lowest point.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	2	Product	Yes	Pass
The sump contained product.															
Pump Sump	Veeder-Root	TLS-320	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	2	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Water/Product	NT	NT	NT	NT	NT	10	5	Product	Yes	Pass
Sensor was sitting in 3-4 inches of water/product but was not in alarm. However, sensor activated alarm when flipped.															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	NA	NA	Clean/Dry	NT	NT	NT	NT	NT	5	3	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Unk	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Unk	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	NA	NA	Clean/Dry	NT	NT	NT	NT	NT	5	3	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Contractor mentioned that this type of sensors are constantly cracking and split out in age(chronic problem). Maybe it's a design problem. Even when sensors are cracked, contractor usually don't replace them.															
Tank Interstice	Veeder-Root	Unk	No	Yes	Water	NT	NT	NT	NT	NT	4	4	Product	Yes	Pass
Interstitial space is full of water. Technician could not put back the sensor without calling the maintenance to remove water. Sensor was not at lowest point and wire was wrapped up.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Sensor casing was corroded and cracked. This is a chronic problem with this model. Even when cracked, contractor does not replace them because they all tend to be like that after a while.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	Unk	No	Yes	Water	NT	NT	NT	NT	NT	4	4	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	NA	NA	Clean/Dry	NT	NT	NT	NT	NT	5	3	Product	NP	Pass
Tank Interstice	Veeder-Root	Unk	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	25	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	Unk	Product	NP	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Tank Interstice	Pneumeractor	LC-1000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Tank Interstice	Pneumeractor	LC-1000	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Water	NT	NT	NT	NT	NT	5	Unk	Product	NP	Pass
Sensor was wet when removed from tank interstice. It is unknown how much liquid was in interstice.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	Unk	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	Unk	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	NA	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	NA	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	3	3	Product	NA	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	10	Unk	Product	NP	Pass
.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	Unk	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass

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Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice	Veeder-Root	TLS-300	No	Yes	Clean/Dry	NT	NT	NT	NT	NT	30	Unk	Product	NP	Pass
This sensor is for steel tanks, and could not be wrapped around the FG tank. Local agency instructed owner to replace.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	None	NA	Both	NP	Fail
Original sensor was stuck in the interstice because of rust on casing; sensor was replaced. New sensor passed test.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	5	5	Product	Yes	Pass	NT	NT	NT	NT	NT
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	Unk	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Steel sensor casing was split.															
Tank Interstice	Gilbarco	EMC	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Steel sensor casing was split.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	1	1	Both	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	3	3	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	NA	Yes	Clean/Dry	NT	NT	NT	NT	NT	None	NA	None	NP	Fail
The sensor was missing the float. Follow up was made with local agency and confirmed that the technician repaired the sensor. However, inspector did not perform re-inspection.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass

All times are recorded in seconds and heights in inches.

Sensor Location	Panel Make	Panel Model	At Low Point	Wiring OK	Condition of Location	Liquid Testing					Flip Testing				
						Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Sensor housing (steel bell) was split.															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	2	2	Product	Yes	Pass
Sensor Model: 794390-460															
Operating Principle: Float Switch															
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
Tank Interstice	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	5	5	Product	NP	Pass
UDC	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	4	1	Product	Yes	Pass
Sensor Model: 847990-001															
Operating Principle: Float Switch															
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	20	5	Both	Yes	Pass
Pump Sump	Veeder-Root	TLS-350	Yes	Yes	Clean/Dry	NT	NT	NT	NT	NT	20	5	Both	Yes	Pass
UDC	Dispenser Cut-off	Unk	Yes	Yes	Clean/Dry	1	MR	Unk	NA	Pass	NT	NT	NT	NT	NT
The sensor cuts power to dispensers. Dispenser had to be manually reset to clear alarm.															
UDC	Dispenser Cut-off	Unk	Yes	Yes	Clean/Dry	2	MR	Unk	NA	Pass	NT	NT	NT	NT	NT
The sensor cuts power to dispensers. Dispenser had to be manually reset to clear alarm.															
UDC	Dispenser Cut-off	Unk	Yes	Yes	Clean/Dry	3	MR	Unk	NA	Pass	NT	NT	NT	NT	NT
The sensor cuts power to dispensers. Dispenser had to be manually reset to clear alarm.															
UDC	Dispenser Cut-off	Unk	Yes	Yes	Clean/Dry	2	MR	Unk	NA	Pass	NT	NT	NT	NT	NT
The sensor cuts power to dispensers. Dispenser had to be manually reset to clear alarm.															
Sensor Make: Warrick Controls															
Sensor Model: DLP-1-NC															
Operating Principle: Float Switch															
Pump Sump	Warrick	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	None	NA	None	NP	Fail
Sensor was sitting in water and not alarmed. Contractor shook sensor and float moved activating the alarm. Sensor passed retest after 1-2 second alarm response.															
Pump Sump	Warrick	Unk	Yes	Yes	Water	NT	NT	NT	NT	NT	Unk	Unk	Both	NP	Pass

APPENDIX VI, TABLE 3
Field Data for Discriminating Sensors

TABLE 3 - Field Data for Discriminating Sensors

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Make: <i>Alpha wire</i>																			
Sensor Model					Unk														
NT	NT	NT	NT	NT	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	60	60	Product	NP	Pass
NT	NT	NT	NT	NT	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	None	NA	None	NP	Fail
Sensor Make: <i>Emco</i>																			
Sensor Model					Q0003-001														
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
Sensor Model					Q0003-002														
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	60	Water	NA	Pass	60	60	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	60	Water	NA	Pass	60	60	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
60	Unk	Water	NA	Pass	60	Unk	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not require discriminating sensors to be tested in product.																			
Sensor Make: <i>Incon</i>																			
Sensor Model					TSP-DIS														
4	Unk	Both	Yes	Pass	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA

Sensor Make: *Mallory Controls*

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Model Pollulert FD 221GTRA																			
10	Dry	Water	NA	Pass	NA	NA	NA	NA	NA	10	Dry	Product	NA	Pass	NA	NA	NA	NA	NA
Sensor had to be wiped dry to come out of alarm.																			
10	Dry	Water	NA	Pass	NA	NA	NA	NA	NA	10	Dry	Product	NA	Pass	NA	NA	NA	NA	NA
Sensor had to be wiped dry to come out of alarm.																			
10	Dry	Water	NA	Pass	NA	NA	NA	NA	NA	10	Dry	Product	NA	Pass	NA	NA	NA	NA	NA
Sensor had to be wiped dry to come out of alarm.																			
Sensor Model Pollulert MD 241RRA																			
10	Dry	Water	NA	Pass	NA	NA	NA	NA	NA	10	Dry	Product	NA	Pass	NA	NA	NA	NA	NA
Sensor had to be wiped dry to come out of alarm.																			
10	Dry	Water	NA	Pass	NA	NA	NA	NA	NA	10	Dry	Product	NA	Pass	NA	NA	NA	NA	NA
Sensor had to be wiped dry to come out of alarm.																			
10	Dry	Water	NA	Pass	NA	NA	NA	NA	NA	10	Dry	Product	NA	Pass	NA	NA	NA	NA	NA
Sensor had to be wiped dry to come out of alarm.																			
NT	NT	NT	NT	NT	NA	NA	NA	NA	NA	10	10	Product	Yes	Pass	NA	NA	NA	NA	NA
NT	NT	NT	NT	NT	NA	NA	NA	NA	NA	NA	NA	None	No	Fail	NA	NA	NA	NA	NA
Sensor failed the test, but the company is out of business. So, owner might have to change the system. Inspector gave the owner two weeks to fix it or replace it.																			
NT	NT	NT	NT	NT	NA	NA	NA	NA	NA	20	10	Product	Yes	Pass	NA	NA	NA	NA	NA
Sensor Make: <i>Red Jacket</i>																			
Sensor Model RE400-203																			
1	1	Water	NA	Pass	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
1	1	Water	NA	Pass	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
1	1	Water	NA	Pass	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
1	1	Water	NA	Pass	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
1	1	Water	NA	Pass	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
1	1	Water	NA	Pass	NA	NA	NA	NA	NA	NT	NT	NT	NT	NT	NA	NA	NA	NA	NA
Sensor Make: <i>Veeder-Root</i>																			
Sensor Model 794380-320																			
Unk	Unk	Unk	Unk	Unk	2	5	Water	Unk	Pass	383	1030	Product	Unk	Pass	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	1	7	Water	Unk	Pass	395	962	Product	Unk	Pass	NA	NA	NA	NA	NA
Sensor Model 794380-322																			
5	Unk	Water	NA	Pass	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Technician flipped the sensor, activating both low and high water alarms at the same time.																			

All times are recorded in seconds and heights in inches.

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Sensor Model					794380-341														
NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	5	1	Product	Yes	Pass	NA	NA	NA	NA	NA
When placed in fuel, alarms went off as water - pump shut-down worked; waste oil sensor failed, replaced and recorded on separate sheet.																			
10	10	Water	Yes	Pass	NA	NA	NA	NA	NA	10	10	Water	Yes	Fail	NA	NA	NA	NA	NA
Technician had to clean the sensor with a rag completely (especially in the small window at sensor's center) before fuel could be detected. After cleaning sensor did detect fuel.																			
10	10	Water	Yes	Pass	NA	NA	NA	NA	NA	10	10	Water	Yes	Fail	NA	NA	NA	NA	NA
Technician had to clean the sensor with a rag completely (especially in the small window at sensor's center) before fuel could be detected. After cleaning sensor did detect fuel.																			
10	10	Water	Yes	Pass	NA	NA	NA	NA	NA	10	10	Water	Yes	Fail	NA	NA	NA	NA	NA
Technician had to clean the sensor with a rag completely (especially in the small window at sensor's center) before fuel could be detected. After cleaning sensor did detect fuel.																			
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	NA	NA	None	Unk	Fail	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	2	2	Product	Unk	Pass	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	2570	4240	Product	Unk	Pass	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	5	5	Product	Unk	Pass	NA	NA	NA	NA	NA
3	3	Water	Yes	Pass	NA	NA	NA	NA	NA	3	3	Product	Yes	Pass	NA	NA	NA	NA	NA
12	1	Water	NA	Pass	NA	0	NA	NA	NA	13	Unk	Water	No	Fail	NA	NA	NA	NA	NA
Sensor sets water alarm for product test. After testing the sensor was replaced and the new sensor was setting the right alarm.																			
NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	5	1	Product	Yes	Pass	NA	NA	NA	NA	NA
NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	5	1	Product	Yes	Pass	NA	NA	NA	NA	NA
NT	NT	NT	NT	NT	NA	NA	NA	NA	NA	Unk	Unk	None	No	Fail	NA	NA	NA	NA	NA
Replaced with same type of sensor.																			
3	2	Both	Yes	Pass	NA	NA	NA	NA	NA	3	2	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor had been programmed to give the same alarm in water and product.																			
3	2	Both	Yes	Pass	NA	NA	NA	NA	NA	3	2	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor had been programmed to give the same alarm in water and product.																			
3	2	Both	Yes	Pass	NA	NA	NA	NA	NA	3	2	Both	Yes	Pass	NA	NA	NA	NA	NA
Sensor had been programmed to give the same alarm in water and product.																			
3	3	Water	Yes	Pass	NA	NA	NA	NA	NA	3	3	Water	Yes	Fail	NA	NA	NA	NA	NA
Detected product as water. Since pump shuts down for product or water, Local Agency did not require sensor to be changed. Owner will replace sensor or re-program as non-discriminating.																			
12	1	Water	NA	Pass	NA	0	NA	NA	NA	13	Unk	Product	Yes	Pass	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	2	2	Product	Unk	Pass	NA	NA	NA	NA	NA
12	1	Water	NA	Pass	NA	0	NA	NA	NA	12	Unk	Water	No	Fail	NA	NA	NA	NA	NA
Sensor sets water alarm for product test. After testing, sensor was replaced and the new sensor was setting the right alarm.																			
NT	NT	NT	NT	NT	NA	0	NA	NA	NA	13	Unk	Water	NA	Fail	NA	NA	NA	NA	NA
Sensor was tested with both unleaded gasoline and waste oil. Both cases, water alarms were observed. Sensor was not approved for use in waste oil. After testing, sensor was replaced and it passed the product test.																			
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	NA	NA	None	Unk	Fail	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	3	10	Water	Unk	Pass	358	2450	Product	Unk	Pass	NA	NA	NA	NA	NA

All times are recorded in seconds and heights in inches.

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	4	10	Product	Unk	Pass	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	NA	NA	NA	NA	NA	417	1055	Product	Unk	Pass	NA	NA	NA	NA	NA
3	3	Water	Yes	Pass	NA	NA	NA	NA	NA	3	3	Water	Yes	Fail	NA	NA	NA	NA	NA
Detected product as water. Since pump shuts down for product or water, Local Agency did not require sensor to be changed. Owner will replace sensor or reprogram as non-discriminating.																			
Sensor Model				794380-350															
5	5	Water	NA	Pass	5	5	Water	Yes	Pass	360	465	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
1	1	Water	NA	Pass	5	5	Water	Yes	Pass	360	765	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
2	2	Water	NA	Pass	2	2	Water	Yes	Pass	300	480	Product	Yes	Pass	NA	NA	NA	NA	NA
2	2	Water	NA	Pass	2	Unk	Water	Yes	Pass	480	Non	Product	Yes	Fail	NA	NA	NA	NA	NA
Sensor did not come out of alarm after being tested in product, so technician replaced it.																			
2	2	Water	NA	Pass	None	Non	None	No	Fail	none	Unk	None	No	Fail	NA	NA	NA	NA	NA
Sensor did not respond during high water or product testing. Technician suspected wiring problem, since sensor was replaced but test results did not change.																			
2	2	Water	NA	Pass	2	2	Water	Yes	Pass	180	NA	Product	Yes	Pass	NA	NA	NA	NA	NA
2	2	Water	NA	Pass	2	2	Water	No	Fail	Unk	Unk	Product	No	Fail	NA	NA	NA	NA	NA
Technician suspected a problem with the wiring at this site.																			
5	5	Water	NA	Pass	5	5	Water	NA	Pass	480	300	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
1	1	Water	NA	Pass	5	5	Water	Yes	Pass	330	600	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
5	Unk	Water	NA	Pass	2	2	Water	Yes	Pass	300	600	Product	Yes	Pass	NA	NA	NA	NA	NA
Sensors were left in fuel for 3 minutes. They alarm 2-5 minutes after being pulled from fuel. This speeds up recovery time.																			
5	5	Water	NA	Pass	5	5	Water	Yes	Pass	300	360	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
5	5	Water	NA	Pass	5	5	Water	Yes	Pass	330	420	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
5	5	Water	NA	Pass	5	5	Water	NA	Pass	300	540	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
5	5	Water	NA	Pass	5	5	Water	NA	Pass	720	360	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
5	5	Water	NA	Pass	5	5	Water	NA	Pass	360	1500	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			
5	Unk	Water	NA	Pass	2	2	Water	Yes	Pass	420	720	Product	Yes	Pass	NA	NA	NA	NA	NA
Sensors were left in fuel for 3 minutes. They alarm 2-5 minutes after being pulled from fuel. This speeds up recovery time.																			
1	1	Water	NA	Pass	5	5	Water	Yes	Pass	300	540	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.																			

All times are recorded in seconds and heights in inches.

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
7	1	Water	NA	Pass	3	1	Water	Yes	Pass	360	720	Product	Yes	Pass	NA	NA	NA	NA	NA
For product test, sensor was left in fuel for 3 minutes.					NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	NA	NA	NA	NA	NA
NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	360	900	Product	Yes	Pass	NA	NA	NA	NA	NA
NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	360	900	Product	Yes	Pass	NA	NA	NA	NA	NA
NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	360	900	Product	Yes	Pass	NA	NA	NA	NA	NA
NT	NT	NT	NT	NT	5	1	Water	Yes	Pass	840	Unk	Product	Yes	Pass	NA	NA	NA	NA	NA
Takes longer for this sensor to alarm because often left sitting in water.					7	1	Water	NA	Pass	5	1	Water	Yes	Pass	NA	NA	NA	NA	NA
For product test, sensor was left in fuel for 3 minutes.					7	1	Water	NA	Pass	4	1	Water	Yes	Pass	NA	NA	NA	NA	NA
For product test, sensor was left in fuel for 3 minutes.					7	1	Water	NA	Pass	5	1	Water	Yes	Pass	NA	NA	NA	NA	NA
For product test, sensor was left in fuel for 3 minutes.					Unk	Unk	Unk	Unk	Unk	4	5	Water	Unk	Pass	NA	NA	NA	NA	NA
7	1	Water	NA	Pass	6	1	Water	Yes	Pass	360	1020	Product	Yes	Pass	NA	NA	NA	NA	NA
For product test, sensor was left in fuel for 3 minutes.					5	Unk	Water	NA	Pass	2	2	Water	Yes	Pass	NA	NA	NA	NA	NA
Sensors were left in fuel for 3 minutes. They alarm 2-5 minutes after being pulled from fuel. This speeds up recovery time.					Unk	Unk	Unk	Unk	Unk	2	10	Water	Unk	Pass	NA	NA	NA	NA	NA
Unk	Unk	Unk	Unk	Unk	4	7	Water	Unk	Pass	357	890	Product	Unk	Pass	NA	NA	NA	NA	NA
2	2	Water	NA	Pass	2	2	Water	No	Fail	Unk	Unk	Product	No	Fail	NA	NA	NA	NA	NA
Sensor alarmed, but failed PSD. Problem with the relay is suspected.					Unk	Unk	Unk	Unk	Unk	3	9	Water	Unk	Pass	NA	NA	NA	NA	NA
5	Unk	Water	NA	Pass	2	2	Water	Yes	Pass	300	600	Product	Yes	Pass	NA	NA	NA	NA	NA
Sensors were left in fuel for 3 minutes. They alarm 2-5 minutes after being pulled from fuel. This speeds up recovery time.					5	5	Water	NA	Pass	420	420	Product	Yes	Pass	NA	NA	NA	NA	NA
Technician left sensor in product for 2min & 45sec. He rinsed the sensor with soapy water after alarm activated to speed up recovery time.					Unk	Unk	Unk	Unk	Unk	5	10	Water	Unk	Pass	NA	NA	NA	NA	NA
5	Unk	Water	NA	Pass	2	2	Water	Yes	Pass	420	720	Product	Yes	Pass	NA	NA	NA	NA	NA
Sensors were left in fuel for 3 minutes. They alarm 2-5 minutes after being pulled from fuel. This speeds up recovery time.					7	1	Water	NA	Pass	6	1	Water	Yes	Pass	NA	NA	NA	NA	NA
For product test, sensor was left in fuel for 3 minutes.					Unk	Unk	Unk	Unk	Unk	4	9	Water	Unk	Pass	NA	NA	NA	NA	NA
5	Unk	Water	NA	Pass	2	2	Water	Yes	Pass	300	600	Product	Yes	Pass	NA	NA	NA	NA	NA
Sensors were left in fuel for 3 minutes. They alarm 2-5 minutes after being pulled from fuel. This speeds up recovery time.																			
Sensor Model					794380-352														
3	1	Both	Yes	Pass	3	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

All times are recorded in seconds and heights in inches.

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
6	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sensors were tested as a non-discriminating float sensor.																			
6	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sensors were tested as a non-discriminating float sensor.																			
NT	NT	NT	NT	NT	5	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
These sensors were located in the fill sump, in the overflow bucket.																			
NT	NT	NT	NT	NT	1	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
These sensors were located in the fill sump, in the overflow bucket.																			
NT	NT	NT	NT	NT	5	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
These sensors were located in the fill sump, in the overflow bucket.																			
3	1	Both	Yes	Pass	3	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10	5	Water	NA	Pass	10	5	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Flip test activated both low and high liquid alarms. Technician did not test the sensor in product.																			
10	5	Water	NA	Pass	10	5	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Flip test activated both low and high liquid alarms. Technician did not test the sensor in product.																			
10	5	Water	NA	Pass	10	5	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Flip test activated both low and high liquid alarms. Technician did not test the sensor in product.																			
15	5	Water	NA	Pass	15	5	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Flip test activated both low and high liquid alarms. Technician did not test the sensor in product. Water in sump was not high enough to activate the alarm.																			
5	Unk	Water	NA	Pass	5	Unk	Water	Unk	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not test discriminating sensors in product. Both low and high level alarms were activated by flipping the sensor.																			
5	Unk	Water	NA	Pass	5	Unk	Water	Unk	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Local agency did not test discriminating sensors in product. Both low and high level alarms were activated by flipping the sensor.																			
Unk	Unk	None	No	Fail	3	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sensor's low float did not activate (would not reset). Sensor was replaced by the owner without informing the local agency nor the contractor who does the routine inspection. Apparently, they did not retest sensor's functionality.																			
Unk	Unk	Unk	Unk	Unk	10	17	Water	Unk	Pass	425	2435	Product	Unk	Pass	NT	NT	NT	NT	NT
Cleaned in Coleman Fuel.																			
Unk	Unk	Unk	Unk	Unk	8	16	Water	Unk	Pass	446	1548	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	12	18	Water	Unk	Pass	468	960	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	4	10	Water	Unk	Pass	452	960	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	11	Water	Unk	Pass	NA	NA	Water	Unk	Fail	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	NT	NT	NT	NT	NT	543	570	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	10	18	Water	Unk	Pass	275	2595	Product	Unk	Pass	NT	NT	NT	NT	NT
Cleaned in Coleman Fuel.																			
6	1	Both	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sensors were tested as a non-discriminating float sensor.																			
Unk	Unk	Unk	Unk	Unk	7	13	Water	Unk	Pass	425	1413	Product	Unk	Pass	NT	NT	NT	NT	NT

All times are recorded in seconds and heights in inches.

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Unk	Unk	Unk	Unk	Unk	6	16	Water	Unk	Pass	435	2040	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	9	22	Water	Unk	Pass	530	2040	Product	Unk	Pass	NT	NT	NT	NT	NT
Cleaned in Coleman Fuel.																			
Unk	Unk	Unk	Unk	Unk	4	14	Water	Unk	Pass	355	1640	Product	Unk	Pass	NT	NT	NT	NT	NT
Cleaned in Coleman Fuel.																			
Unk	Unk	Unk	Unk	Unk	5	13	Water	Unk	Pass	414	1240	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	5	12	Water	Unk	Pass	379	1143	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	16	Water	Unk	Pass	429	1166	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	8	21	Water	Unk	Pass	422	1320	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	5	12	Water	Unk	Pass	425	1271	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	4	9	Water	Unk	Pass	483	1229	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	7	13	Water	Unk	Pass	299	573	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	4	13	Water	Unk	Pass	318	481	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	4	11	Water	Unk	Pass	397	690	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	10	Water	Unk	Pass	489	1190	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	5	11	Water	Unk	Pass	539	1631	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	4	9	Water	Unk	Pass	474	1299	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	9	15	Water	Unk	Pass	495	1256	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	14	Water	Unk	Pass	Unk	813	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	16	Water	Unk	Pass	335	2010	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	2	12	Water	Unk	Pass	470	1078	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	4	11	Water	Unk	Pass	350	3499	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	5	10	Water	Unk	Pass	459	1769	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	14	Water	Unk	Pass	462	2206	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	5	11	Water	Unk	Pass	453	930	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	13	Water	Unk	Pass	440	1140	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	8	19	Water	Unk	Pass	420	1851	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	5	13	Water	Unk	Pass	540	1760	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	9	11	Water	Unk	Pass	360	1500	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	8	21	Water	Unk	Pass	354	1807	Product	Unk	Pass	NT	NT	NT	NT	NT
NT	NT	NT	NT	NT	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	5	5	Water	Yes	Pass
Sensor was programmed for PSD on high-liquid only, not product. Technician re-programmed for PSD on low, high, and product.																			

All times are recorded in seconds and heights in inches.

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
NT	NT	NT	NT	NT	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	3	5	Water	Yes	Pass
Sensor was programmed for PSD on high-liquid only, not product. Technician re-programmed for PSD on low, high, and product.																			
NT	NT	NT	NT	NT	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	3	5	Water	Yes	Pass
Sensor was programmed for PSD on high-liquid only, not product. Technician re-programmed for PSD on low, high, and product.																			
NT	NT	NT	NT	NT	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	5	5	Water	Yes	Pass
Sensor was programmed for PSD on high-liquid only, not product. Technician re-programmed for PSD on low, high, and product.																			
NT	NT	NT	NT	NT	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	5	Unk	Water	NP	Pass
10	2	Water	NA	Pass	2	2	Water	Yes	Pass	260	Unk	Product	Yes	Pass	NT	NT	NT	NT	NT
Programmed for "high vapor mode".																			
NT	NT	NT	NT	NT	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	5	Unk	Water	NP	Pass
3	3	Water	NA	Pass	2	2	Water	Yes	Pass	240	Unk	Product	Yes	Pass	NT	NT	NT	NT	NT
Programmed for "high vapor mode". Sensor intermittently activated "sensor out" alarm when being moved. Technician suspected a short in wiring where cable attaches to sensor.																			
Unk	Unk	Unk	Unk	Unk	5	14	Water	Unk	Pass	730	1276	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	13	21	Water	Unk	Pass	480	600	Product	Unk	Pass	NT	NT	NT	NT	NT
NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Wiring malfunctioning.																			
NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Wiring malfunctioning.																			
NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
NT	NT	NT	NT	NT	60	5	Water	Yes	Pass	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Had 2 bad relays that had to be fixed.																			
NT	NT	NT	NT	NT	10	5	Water	Yes	Pass	NT	NT	NT	NT	NT	5	Unk	Water	NP	Pass
Unk	Unk	Unk	Unk	Unk	10	24	Water	Unk	Pass	520	1769	Product	Unk	Pass	NT	NT	NT	NT	NT
NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Had 2 bad relays that had to be fixed.																			
Unk	Unk	Unk	Unk	Unk	13	24	Water	Unk	Pass	420	1978	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	18	25	Water	Unk	Pass	385	1470	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	12	25	Water	Unk	Pass	412	1920	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	12	25	Water	Unk	Pass	400	1695	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	15	28	Water	Unk	Pass	335	2281	Product	Unk	Pass	NT	NT	NT	NT	NT
NT	NT	NT	NT	NT	5	5	Water	Yes	Pass	NT	NT	NT	NT	NT	5	5	Water	Yes	Pass
Sensor was programmed for PSD on high-liquid only, not product. Technician re-programmed for PSD on low, high, and product.																			
Unk	Unk	Unk	Unk	Unk	16	30	Water	Unk	Pass	Unk	Unk	Product	Unk	Pass	NT	NT	NT	NT	NT
Emergency shut-off activated during testing, so no data was available.																			
Unk	Unk	Unk	Unk	Unk	8	19	Water	Unk	Pass	420	1625	Product	Unk	Pass	NT	NT	NT	NT	NT

All times are recorded in seconds and heights in inches.

<i>Low Water Test</i>					<i>High Water Test</i>					<i>Product Testing</i>					<i>Flip Testing</i>				
Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result	Resp	Rec	Alarm	PSD	Result
Unk	Unk	Unk	Unk	Unk	9	19	Water	Unk	Pass	NA	NA	None	Unk	Fail	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	6	15	Water	Unk	Pass	600	2120	Product	Unk	Pass	NT	NT	NT	NT	NT
Unk	Unk	Unk	Unk	Unk	10	18	Water	Unk	Pass	600	2120	Product	Unk	Pass	NT	NT	NT	NT	NT
15	Unk	Water	NA	Pass	5	Unk	Water	Yes	Pass	300	Unk	Product	Yes	Pass	NT	NT	NT	NT	NT
15	Unk	Water	NA	Pass	6	Unk	Water	Yes	Pass	390	Unk	Product	Yes	Pass	NT	NT	NT	NT	NT
15	2	Water	NA	Pass	15	3	Water	Yes	Pass	270	Unk	Product	Yes	Pass	NT	NT	NT	NT	NT
2	2	Product	Yes	Pass	2	2	Product	Yes	Pass	3	Unk	Product	Yes	Pass	NT	NT	NT	NT	NT
Programmed for "high vapor mode". Sensor was saturated with product vapors, so any liquid moving low or high float registered as a product alarm.																			
Unk	Unk	Unk	Unk	Unk	16	41	Water	Unk	Pass	450	1559	Product	Unk	Pass	NT	NT	NT	NT	NT

APPENDIX VII

Discussion of Point Liquid and Polymer Strip Discriminating Sensors

Point Liquid and Polymer Strip Discriminating Sensors

Point liquid type sensors use solid state electronics, which measure a particular physical property or properties of liquid that contacts the detection element. An example is capacitance change sensors, where liquid contacting the detection element acts as the dielectric in a capacitor. Air (no liquid present at sensor), hydrocarbon-based liquids, and water each have distinctly different dielectric constants. A capacitance change sensor can detect this and respond differently when dry, or when exposed to water or hydrocarbons. Different responses from the sensor are interpreted by the control panel, which activates the appropriate alarm.

Point liquid discriminating sensors are capable of responding only to liquids directly in contact with the detection element. This means that product floating on water will produce a water alarm if only the water is in contact with the detection element. The detection elements are usually quite small, meaning that it does not take a great deal of water to potentially mask a product release. Point liquid discriminating sensors tend to be smaller than the polymer strip type, and contain no moving parts. These attributes allow them to be installed in a variety of orientations, and in tight spaces (such as a tank interstice) where polymer strip sensors would not fit. Response time for this type of sensor varies by manufacturer and model, but is generally quick (less than 1 minute).

In contrast to point liquid discriminating sensors, polymer strip sensors use two detection elements combined in one housing to discriminate between product and water*. The first detection element is a float switch or ultrasonic detector that will activate a “low liquid level” alarm when in contact with any liquid. It is located near the bottom of the sensor, and generally has a quick response time (less than 1 minute). The second detection element is a hydrocarbon-sensing cable or strip that will activate a “product” alarm when exposed to hydrocarbon-based product. It will not respond to water. The cable or strip typically runs from the bottom to the top of the sensor, and response times vary between approximately 5 minutes and 20 minutes in unleaded fuel (may be 12 hours or more in diesel fuel).

It is only by combining the float or ultrasonic liquid-sensing element with the hydrocarbon-sensing element (cable or strip) that the polymer strip type sensor is able to discriminate between product and water. A liquid entering the area monitored by the sensor will first contact the lowest float or ultrasonic detection element, activating a “low liquid level” alarm. This alarm alerts the UST operator that liquid is present in the monitored area. If the liquid present is gasoline, the hydrocarbon-sensing element will activate a “product” alarm approximately 5 to 20 minutes later (may be 12 hours or more for diesel fuel). In this event, the UST operator knows that product is present in the area monitored by the sensor, not just water.

Polymer strip discriminating sensors offer the benefit of being able to detect a layer of hydrocarbon floating on water, as long as the water level is in contact with the hydrocarbon-sensing strip. This makes them well suited for locations where water ingress is common. Many (but not all) of these sensors have an additional float or ultrasonic liquid-sensing element located at the top end of the hydrocarbon-sensing strip. This element activates a “high liquid level” alarm, which indicates that the liquid level has exceeded the height of the hydrocarbon-sensing strip. Once water has reached this level, subsequent product releases may float above and fail to contact the hydrocarbon-sensing strip, resulting in a missed detection. Polymer strip type sensors are less likely to miss a layer of product on water than point liquid discriminating sensors, but it is still a possibility that UST operators and inspectors should be aware of.

* Examples of polymer strip discriminating sensors include Emco Electronics models Q0003-002 and -003, Incon models TSP-DDS and TSP-DTS, and Veeder-Root models 794380-320, -322, -350, and -352).